

JOURNAL OF THE
BOSTON SOCIETY
OF
CIVIL ENGINEERS



MAY - 1932

VOLUME XIX

NUMBER 5

BOSTON SOCIETY OF CIVIL ENGINEERS

OFFICERS, 1932-1933

PRESIDENT

RALPH W. HORNE

VICE-PRESIDENTS

ARTHUR W. DEAN

(Term expires March, 1933)

JOHN B. BABCOCK, 3d

(Term expires March, 1934)

SECRETARY

EVERETT N. HUTCHINS

TREASURER

KARL R. KENNISON

DIRECTORS

GORDON M. FAIR

ARTHUR D. WESTON

(Term expires March, 1933)

JOHN C. MOSES

EDWARD WRIGHT

(Term expires March, 1934)

PAST PRESIDENTS

FRANK E. WINSOR

LEWIS E. MOORE

HARRY E. SAWTELL

SANITARY SECTION

STUART E. COBURN, Chairman

FRANK L. FLOOD, Clerk

DESIGNERS SECTION

LAWRENCE G. ROPES, Chairman

HERMAN G. DRESSER, Clerk

HIGHWAY SECTION

FRANCIS T. McAVOY, Chairman

ARTHUR P. RICE, Clerk

NORTHEASTERN UNIVERSITY SECTION

JOHN B. KOMICH, Chairman

RICHARD D. MURPHY, Clerk

Editor — EVERETT N. HUTCHINS

715 Tremont Temple

JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

Volume XIX

MAY, 1932

Number 5

CONTENTS

PAPERS AND DISCUSSIONS

	PAGE
Recent Developments in the Design and Construction of Highways. <i>Raymond W. Coburn</i>	281
Discussion	290
Recent Developments in the Maintenance and Use of Highways. <i>George H. Delano</i>	293
Discussion	301
The Design of Concrete Form Work. <i>Joseph Tucker</i>	304

OF GENERAL INTEREST

Memoirs:	
William Fish Williams	311
Clemens Herschel	313
Hector James Hughes	317
Allen Hazen	319
Proceedings	322

Published Monthly, except July and August, by the Society
715 Tremont Temple, Boston, Massachusetts

Subscription Price, \$4.00 a Year (10 Copies)
50 Cents a Copy

Copyright, 1932, by the Boston Society of Civil Engineers.
Entered as second-class matter, January 15, 1914, at the Post Office
at Boston, Mass., under Act of August 24, 1912.

Acceptance for mailing at special rate of postage provided for in
Section 1103, Act of October 3, 1917, authorized on July 16, 1918.

*The Society is not responsible for any statement made or opinion
expressed in its publications.*

BOSTON
WRIGHT & POTTER PRINTING COMPANY
32 DERNE STREET

JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

Volume XIX

MAY, 1932

Number 5

RECENT DEVELOPMENTS IN THE DESIGN AND CONSTRUCTION OF HIGHWAYS

RAYMOND W. COBURN,* Member

(Presented at a meeting of the Boston Society of Civil Engineers, February 17, 1932)

THE building of highways during the past year, both in the number of miles constructed and in the millions of dollars expended, has reached a height never before attained. It has become the greatest single Public Works activity that the world has ever known. The expenditures for the entire country, during 1931, covering State highway construction and maintenance, has been estimated as \$1,000,000,000.

It is only natural in a growing industry or activity of the above proportions that certain trends or developments should take place which stand out as being of recent origin and of major importance.

The enumeration of these recent developments and trends, both in the design and the construction of highways, has been taken as the subject for this paper.

In reviewing the evolution of highway building during the last few years it seems to me that almost without exception all important developments can be traced to two fundamental principles: first, highway safety, and second, highway economics.

The highway engineer has given much thought to a design that will build safety into the highway and will keep the travel flowing without interruption, and along with the contractor and the machinery-

* Construction Engineer, Massachusetts Department of Public Works, State House, Boston.

man he has been alert to the possibilities of building a better road for less money.

BOSTON AND WORCESTER TURNPIKE

Probably the outstanding development in State highway construction during the last few years, at least in the New England States, has been the construction of a 17-mile section of double-barrel highway in Massachusetts, on the line of the old Boston and Worcester Turnpike, between the city of Worcester and Framingham Center.

This double-barrel highway, or divided road, with its many grade separations and connecting ramps, with its improved alignment and smooth vertical curves, with its two lanes of cement concrete each side of a grass zone of safety, bordered on the outside with parking shoulders 10 feet in width, is undoubtedly a forward step in highway design and safety, and one that, with certain modifications, will be used more and more in the future.

This divided roadway removes the headlight glare from approaching traffic, permits free movement of opposing traffic lines, makes passing at summits in the grade safe, helps pedestrians to cross the road safely, and practically makes the head-on collision impossible. Furthermore, it is probably 33 per cent more efficient than any four-lane, undivided road, as experience demonstrates that the 40-foot undivided pavement is used as a three-lane road much of the time.

The 17-mile section of highway mentioned above is only about one-half of the total Boston and Worcester Turnpike project, and with the completion of the second half into Boston, a part of which is now under construction, the entire project will give the State of Massachusetts one of the outstanding highways of the country.

ELIMINATION OF RAILROAD AND HIGHWAY GRADE CROSSINGS

A second important development that has taken place during the last two years, especially in Massachusetts, has been the elimination of grade crossings, including both railroad grade crossings and highway grade crossings. Not counting the bridges that have been rebuilt in order to widen or improve the alignment, there has been built or put under contract within two years no less than thirty-one new structures that will eliminate grade crossings. Thirteen of these structures are at railroad crossings, nine of these being overhead bridges and four being highway underpasses, and the other eighteen are at important highway grade crossings on primary routes.

Of the eighteen highway grade separations previously mentioned, eight are on the new Boston and Worcester Turnpike; two are on the new Worcester by-pass, or "Southwest Connection;" two are on the section of the Circumferential road between Canton and Wellesley; three more are within the Metropolitan District at Revere, Cambridge and Boston, and the remaining three are at Palmer, Andover and Foxborough.

The grade separations on the Boston and Worcester Turnpike are, by all means, the most nearly ideal and the safest, for there, with the divided roadway, it is impossible for traffic on the secondary route to cross the primary route at grade, and, providing connecting ramps are built at all four corners, it will be unnecessary for traffic to make any left-hand turn, and there is no reason why traffic should not flow freely and safely without any interruption.

These highway grade crossing separations mentioned above are the outcome of careful studies that are being made at all important intersections, the aim being to make these route crossings safer and more efficient. In fact, when a cut-off line or a new route is being investigated, one of the most important details to consider is the location of the new intersections, in order that they may be as safe as possible.

TRAFFIC CIRCLES

Other methods used for treating important intersections are the traffic circles and the widening of the pavement through the intersection where traffic lights are to be installed, so that two lines of travel can pass through the intersection, in the same direction, at the same time, when the green light is shown.

Three important traffic circles have been built within the Metropolitan District during the last year, — two on Charles Street, in the city of Boston, and a third in Medford, at the junction of the Fellsway and the Revere Beach Parkway. These circles have worked very satisfactorily, and have safely and economically eliminated badly congested intersections. A fourth traffic circle is now under construction on the State highway at Middleborough, at the point where the road to the Cape highway leaves the Bridgewater-Lakeville Turnpike.

The traffic circle is usually the ideal treatment in a metropolitan area where there are four or more important roads coming into an intersection at various angles, and where the movement of travel is a turning movement in contrast with a crossing movement. To be effective, however, the minimum diameter of a traffic circle should be not

less than 150 feet, in order to permit proper weaving-in of traffic, and if possible the diameter of the circle should increase as the number of entering streets increase.

BY-PASS ROUTES

Another development that is gaining headway each year is the construction of by-pass roads and parallel or alternate routes. Massachusetts built its first by-pass in 1923, at Dighton and Somerset, and since that time a score or more of villages and business centers have been relieved of main through traffic by the construction of a by-pass. As a rule, the motive was to expedite traffic by shortening and straightening the road and to separate the through travel from the local travel, but in some cases there were special reasons, such as —

1. Improving the alignment of the main route.
2. Eliminating the expensive operation of widening existing streets.
3. Avoiding railroad grade crossings.

Although the greatest value of the highway by-pass lies in its ability to expedite through traffic, it is being recognized more and more as a benefit to the community in added safety to local travel and to pedestrians.

The outstanding by-pass built in Massachusetts up to the present time is probably the Middleborough by-pass, built in 1930 on the road to the Cape, between Bridgewater and South Middleborough. This by-pass, or alternate route, is 12 miles long and cost the State about \$750,000.

Within a year, however, two by-passes will have been completed which will surpass the Middleborough project; one, the Worcester by-pass, which is now under construction between Northborough and Auburn, over a route 15 miles long, and which will cost about \$1,800,000; and the other, the Millers Falls-Turners Falls by-pass, which runs from Erving to Greenfield, over a new route approximately 7 miles long and will cost about \$1,000,000.

The distinction between a by-pass route and an alternate or parallel route may be one of definition; as, for example, the new Boston and Worcester Turnpike road and the new Boston and Providence road are spoken of as alternate routes rather than long by-pass routes.

PRELIMINARY DETAILS OF DESIGN

The alignment of the road and the right of way over which the road passes have been given much thought during recent years, and the trend has been towards a wider right of way and a smoother and safer alignment of the road.

To meet the constant increase in volume and speed of traffic, the tendency all over the country is to eliminate dangerous curves or increase the radius of same, and where this cannot be accomplished on existing layouts, new locations are being made to a large extent. In making new locations the needs of the future are anticipated both as to width and alignment. In Massachusetts the minimum width of new locations is generally 80 feet, and the alignment, if possible, is limited to curves of a radius of not less than 2,000 feet. The hazard of limited sight distances on vertical curves has been emphasized by motor vehicle laws and regulations, and as a safety factor, the aim of the highway engineer today is to provide a sight distance of not less than 600 feet, and in some localities not less than 1,000 feet.

The rolling terrain of Massachusetts often prohibits this attainment except at prohibitive cost. In such a case it is the practice to widen the pavement, particularly on three-lane roads, to four lanes where a sight distance of less than 600 feet exists. The limits of the widening are determined by points on the ascending grades where traffic coming over the hill can be seen approximately 600 feet away. Widening is also done on horizontal curves where the sight distance is less than 600 feet.

On the heaviest traveled routes, in order to accommodate the flow of traffic, pavements are now being constructed of greater widths. In Massachusetts, the two-lane bituminous macadam and concrete pavements are being widened to three and four lanes, and on new construction the pavements are 30 and 40 feet wide. In several places the dual type pavement has been used, consisting of one or more lanes of bituminous macadam with a lane of cement concrete on each side. This latter type of pavement, although not originated in Massachusetts, has undoubtedly been brought to a higher perfection and greater use here than in any other State. Its chief merit is that it keeps the traffic on the outside lanes and makes passing easier and safer.

Another recent development in the design of pavements is the trend towards a flatter crown or cross section. This apparently is in answer to the demand for greater safety as the speed of traffic increases.

The tendency all over the country today is for flatter crowns. In Massachusetts the rate of crown for concrete pavements has been reduced from one-fourth inch to three-sixteenths inch per foot, and for bituminous macadam pavements from three-eighths inch to one-fourth inch per foot, and this seems to give a safer cross section, especially on the wider surfaces.

One more recent development in highway design is the more careful attention given to banking curves. Curves of a greater radius are now being banked, as a rule, up to 2,000 feet, and in special cases, such as going down a grade on the outside of a curve, the banking is carried to even larger radii. This has been necessary as the speed of traffic increased, and in most States new standards for banking curves have been brought out during recent years.

NON-SKID SURFACES

Another trend that is evident throughout the country is the attention now being given to the development of non-skid surfaces. Concrete roads are being more positively broom scored in order to roughen the surface of the pavement and provide additional assurance against skidding. Bituminous concrete pavements are being built of coarser aggregates, with the seal coat omitted, or, where sealed, are being covered with stone chips in order to increase the tire traction in wet weather.

The laurel, however, for having developed the best non-skid pavement has come to the State of Massachusetts. Modesty forbids that I say too much about this pavement, but in the highway number of "Engineering News-Record," dated January 7, 1932, an editorial and one of the leading articles pay their respects to this non-skid type of construction, somewhat as follows:

In bituminous macadam construction the most outstanding improvement in recent work has been the elimination of the heavy rich mat seal coat and the production of a waterproof, tightly bonded, but rough texture mosaic surface, in which the large stones take all the wear of traffic and provide a sure and safe grip for vehicle wheels. Such construction has reached a high degree of perfection in Massachusetts.

The above refers to a type of construction that was developed in Massachusetts about twenty years ago, and has been more extensively used than any other type. By gradually reducing the quantity of the seal coat applied, and permitting it to act as a secondary penetration application, we have produced a road surface that has been described by a foreigner as a road that "Looks rough, but rides smooth."

LOW COST SECONDARY ROADS

During the last few years there has been a definite trend in many of the States towards the improvement of secondary roads and the development of low-cost construction. In the States of Pennsylvania and North Carolina legislation was passed in 1931 which added thousands of miles of rural roads to the State highway system, and in several other States there was agitation relative to the highway departments taking over rural highways for improvement.

This trend towards the secondary roads has caused the rapid development of low-cost surfacing, and has stimulated research and study in the use of bituminous materials in combination with local materials. It has brought out several new surfaces, such as the re-tread or mixed in place road, and has lead to a more scientific and extensive use of bituminous materials for surface treatments.

Massachusetts' position in this trend is again as a leader, for as far back as 1897 the old Massachusetts Highway Commission defined as its policy:

First, that the most important of the many needs was that which related to the connection of centers of business; second, the connection of agricultural areas, and of smaller and less populous towns, with a large city or center of dense population, with which they had intimate business relations; and third, the connection with railroads and waterways of the towns remote therefrom, with the ultimate intention of grouping these roads so as to make continuous State highways throughout the Commonwealth

Furthermore, in 1900 legislation was passed which required 5 per cent of the State highway money to be spent in small towns having a valuation of \$1,000,000 or less. Later, in 1912, 10 per cent of the State highway money was made available for small town roads in towns of less than \$1,000,000 valuation, and another 5 per cent for towns with a valuation in excess of \$1,000,000, provided the towns contributed one-half the cost of the work.

This early start, in helping the small towns on their rural roads, has been continued right up to the present time, so that today there is a larger mileage of State aid roads in Massachusetts than there is of State highways. In each of the last half dozen years the mileage of State aid roads built has exceeded the mileage of State highway built, and a very large portion of the State aid roads have been of the low-cost construction, such as gravel, treated gravel and sand asphalt construction.

In addition to the State highway and State aid roads mentioned

above, there are approximately 8,000 miles of town roads maintained with State aid in towns having a valuation of less than \$4,000,000, so that in total, the State Department is contributing in the upkeep of about one-half of all the road mileage within the Commonwealth.

CONCRETE ROAD CONSTRUCTION

One of the trends in concrete road construction during the last few years which has been appreciated most by the general public has been the tendency to open the roads to travel at an earlier date. At first this was done by using calcium chloride in the mix, but today, as a rule, it is due to the better quality of cement used in the pavement. Many of the cement companies today are turning out cement that will meet the 28-day strength requirement in 7 days, and when this quality of cement is used, it is usually possible to open the road to travel in 7 to 10 days, depending on the season of the year. In Massachusetts test beams are cast on the roadside daily and cured the same as the pavement, and broken in about 7 days, and when the beams show a modulus of rupture of 500 pounds per square inch, or better, the road is opened to travel, but in no case in less than 7 days, where standard Portland cement is used.

There has been developed, however, by several of the cement companies, a high early strength cement which will give the required strength in 24 to 48 hours. This type of cement is being used more and more where it is necessary or desirable to open the pavement quickly. This high early strength cement has the same general characteristics as true Portland cement, except that it is ground finer so that five to six times as much will pass the 200-mesh sieve, and, further, it gets its initial set about 1 hour sooner than the average Portland cement and its final set about 2 hours sooner.

Another recent development in concrete road construction is the almost universal adoption of the weight measurement of batches of aggregate. Here the fine and coarse aggregates are weighed separately, usually but not always in separate hoppers, and in some States they require the separation of the coarse aggregate into two sizes to prevent segregation and insure proper grading. The chief advantage of weight measurement is greater accuracy. It eliminates the variations caused by the bulking of moist sand and by the differences in the compaction of the aggregates in the measuring hopper. However, when weight batching is used, the quantity of moisture contained in the aggregates should be determined and a correction made for same in the weight.

Other recent developments in concrete paving are the increased use of bulk cement, which has become universal in several States; the use of truck mixers, which permit the mixing of the concrete while en route to the project; and the introduction of heavy paper for curing the surface of the pavement.

All of these latter developments have been used in Massachusetts, and as each has been brought out for economic reasons, their use will probably continue in the future.

TREATMENT OF SWAMPS

Another recent development that has attracted some attention is the method of treating swamp areas, where they were encountered on highway work. In Massachusetts, when a peat bog or unstable swamp is encountered, one of two treatments is usually prescribed: the soft material is either excavated to hard bottom and backfilled with sandy gravel borrow, or the swamp is loaded with solid material and the underlying soft material displaced by the use of dynamite until the solid fill rests on the hard bottom.

As a rule, where a concrete pavement is to be laid, the first method is used, unless the depth of peat is in excess of 20 feet, and then the decision as to the method to be used will depend on local conditions. Peat has actually been excavated to a depth of 36 feet, and in this case it is interesting to note that the depth 200 feet away was only 3 feet.

When conditions will permit and the swamp material is semi-liquid, it is usually much cheaper to displace the peat and muck with dynamite. On a section of the Worcester Turnpike, in Westborough, a peat bog was blown last year which was about 700 feet long and 30 to 45 feet deep. About 55,000 cubic yards of soft material was displaced for about 18 cents per cubic yard, this being less than one-half of the average bid price for excavating that material. The quantity of dynamite used amounted to about one-fourth pound per cubic yard of material displaced. Before loading and blowing a swamp, it is quite necessary to get a profile and cross sections of the hard bottom, in order properly to plan on the method of procedure.

MODERN MACHINERY AND BID PRICES

In closing, I would like to speak briefly of a few of the recent developments in highway machinery, and show the effect they are having on the trend in highway bid prices.

Mechanical equipment today has revolutionized highway grading in such a way that a contractor who has failed to keep abreast with the new equipment finds himself unable to do the work at the prices bid. The large gasoline shovels with crawler-type traction; the high speed pneumatic-tired trucks; the mechanical graders or road machines, and the "bull-dozers," are cutting the costs of grading by more than one-half. Mechanical equipment for spreading broken stone and bituminous concrete, and new concrete paving mixers with automatic discharge are cutting the surfacing costs almost as much. The trend of average bid prices in Massachusetts has now been downward for six consecutive years, and the highway dollar has undoubtedly bought more during the past year than ever before.

Discussion

COL. FRANK M. GUNBY:* I would like to ask Mr. Coburn the approximate cost per mile of the Worcester Turnpike and a similar figure for the four-lane, cement-concrete roads, and also for a concrete road with black surfacing?

MR. COBURN: The Worcester Turnpike is the most expensive piece of highway building the State has ever undertaken. The expense, including the many grade separations, which added to the cost, averaged about \$200,000 per mile.

There are two types of black road: one type is the sand-asphalt road as laid on the Cape, and the other is the penetration type. For many years the relation between the cost of the Cape type road, the penetration and the macadam concrete road ran in the ratio of 1:2:3. If the Cape road cost \$20,000, the ratio was \$20,000:\$40,000:\$60,000. But those costs are all down today, and that ratio would probably be \$15,000:\$30,000:\$45,000. Prices have gone materially lower in the last few years.

PROF. JAMES W. INGALLS:† What is the typical cross section of the Worcester Turnpike? Is the slab uniform? Is the curb integral with the slab, and how much reinforcing steel is used?

MR. COBURN: The cross section of the Worcester Turnpike includes a 10-foot center area of grass with granite curbing on each side. For a distance of $1\frac{1}{2}$ miles the grass strip is 30 feet wide to provide for a double line of car tracks. On each side of the grass strip there are two lanes of reinforced cement-concrete, each 10 feet wide. The slab is 8 inches

* Associate, Charles T. Main, Inc., 201 Devonshire Street, Boston.

† Department of Industrial Engineering, Northeastern University, Boston.

thick and contains between 9 and 10 pounds of steel bar reinforcement per square yard. The concrete is laid in slabs not over 60 feet in length, with expansion joints between slabs. On the section of the Turnpike most recently built the curbing was set 1 foot away from the concrete slab, and that 1 foot space was filled in with a black strip of bituminous concrete, thereby making the center strip of grass only 8 feet wide. If this cross section is continued toward Boston a slope curbing would be used to permit automobiles to run up over it if necessary.

MR. PHILIP W. TAYLOR:* Will you describe the new type of paving which uses the burlap?

MR. COBURN: The burlap type is a patented pavement. The burlap is not put in for strength, but is put in for weakness, the theory being that a line of weakness 2 inches down from the surface will permit the removal of the top 2 inches when necessary, and the relaying of a new 2-inch wearing surface of a richer mixture. The theory is that it ought to carry travel with less maintenance cost than the ordinary mixture.

QUESTION: Why did you consider the traffic circle more suitable for a metropolitan district?

MR. COBURN: In the metropolitan area travel is not moving so fast as in the country. The tendency of the traffic circle is to slow down traffic, a condition which exists in a metropolitan area.

QUESTION: Has the adoption of liquid asphalt on the center lane proved sufficiently satisfactory to continue its use?

MR. COBURN: Curing oil and emulsified asphalt for curing concrete surfaces have been used in Massachusetts without giving evidence of any harm to the concrete pavement. The Bureau of Public Roads has noted some damage by its use in other parts of the country, due to the fact that the bitumen attracts heat and hair cracks are developed. That action might be troublesome in Tennessee and not in Massachusetts.

When this curing oil and emulsified asphalt were first introduced they were put on the concrete surface within a few hours after the concrete was laid, before it had its initial set. The practice here is to cure the concrete first, for twenty-four hours, with wet burlap, and put the asphalt on the following day. That, I believe, has been approved by the Bureau of Public Roads. It has been used here as an experiment and found to be successful.

QUESTION: After applying the emulsified asphalt do you cover it with any type of stone, dust or chips?

* Of Metcalf & Eddy, Statler Building, Boston.

MR. COBURN: We use only about one-tenth of a gallon, and there is no application of dust or stone of any kind on top of it. No attempt is made to build up a mat which would scale off and be a problem. The prime object was to get a black color, and only incidentally to cure the concrete.

QUESTION: I understand that during the last six or eight years in many States there has been a tendency on concrete roads to use an 8-inch slab with a 10-inch edge, and that this practice has now been adopted in ten or more States.

MR. COBURN: We are using a uniform depth of slab. The thick edges are not being used in the North Atlantic States to the same extent as they are in the West. We believe that a concrete road needs an 8-inch thickness in the center, and that it is a mistake to make it 6 inches; and we feel that if 8 inches is not strong enough the slab should be 9 inches uniformly throughout.

QUESTION: Isn't the curb built as a part of the slab?

MR. COBURN: In the West it is built as part of the slab, but this means added expense and makes the unit price of the concrete higher, and I question if there is any saving with the thickened edge concrete slab. Probably the cost is more per yard for concrete if that includes the curbing.

RECENT DEVELOPMENTS IN THE MAINTENANCE AND USE OF HIGHWAYS

BY GEORGE H. DELANO,* Member

(Presented at a meeting of the Boston Society of Civil Engineers, February 17, 1932)

MAINTENANCE of highways has come to have a much broader scope than the definition of the word would signify. This change in the spirit and character of maintenance was brought about by a change in the use of highways and a change in public requirements, which are briefly as follows:

1. An increase in the volume, weight and speed of traffic using the highways.
2. Economic considerations.
3. Demands for higher standards.
4. A quickened sense of the value of beautiful things.

Increase in volume meant wider surfaces, crown reduction and strengthening or hardening of shoulders; increase in weight meant better and stronger subgrades and surfaces and reduced grades; increase in speed meant better alignment and vision, non-skid surfaces and improved guard rail. Increases in the volume and speed of traffic using the highways also imposed the necessity for warning, guidance and control of traffic.

Economic considerations imposed upon engineers the necessity of providing a greater mileage of highways with surfaces that, while adequate to meet the demands of the traffic using them, would not cost too much to construct and would be susceptible of proper and economical maintenance.

The public has become educated to good road maintenance. Failure to provide it is quickly noted and commented upon, and what the public really wants and is prepared to pay for, it generally obtains; and so it is with the roadsides, — cleanliness, neatness and beauty are demanded and are now being furnished.

The design of highways as today constructed adequately provides for all traffic needs as determined by preliminary traffic studies; all necessary signs and signals are erected by the Maintenance Depart-

* Maintenance Engineer, Massachusetts Department of Public Works, State House, Boston.

ment when construction is completed. This being so, new roads offer but little opportunity for developments in maintenance. The proportion of highways that can be so improved, however, is small when compared to the total, and it is the deficiencies of this large remainder that must be met by maintenance. All classes of highways are included in this latter group, — namely, the highways on the less important of the main routes, also many of those on the secondary routes, and finally the dirt and gravel roads found in every town, — roads which to those who depend on them to get to school or market are the most important in the State.

It is this necessity of rendering highways adequate to meet the traffic demands placed upon them that has been the cause of most of the recent developments. As might be expected, therefore, the more important of these developments cover surfaces, roadsides, snow removal and traffic.

SURFACES

The standard types of surfaces used by highway engineers are, in general, the bituminous macadams, bituminous concretes, cement concretes, etc., possessing considerable strength and stability, but also being expensive to construct and maintain; and other types of surfaces constructed of gravel or broken stone, that while comparatively inexpensive to construct, possessed no great strength, would not carry any great volume or weight of traffic, and were difficult and expensive to maintain. With the rapid increase in the weight and volume of the traffic using all roads, it was found that an intermediate type of surfacing was needed — one that could be used on the road where the traffic did not justify the more expensive type of surface, but which was too heavy for the treated or untreated gravel types.

The "road-mix" method of constructing a surface has been developed to meet this problem. It is sometimes called "re-tread" or "mixed-in-place," but "road-mix" seems more descriptive. It consists of mixing on the roadbed, by machine, a bituminous material with a mineral aggregate consisting of continuously graded run-of-bank gravel, crushed gravel or broken stone of sizes which range in size from $1\frac{1}{2}$ inches down to, and including, fines, or with broken stone ranging in size from $1\frac{1}{4}$ inches to, and including, one-fourth inch. Surfaces in which the continuously graded mineral aggregates are used differ in characteristic from the surfaces obtained where a broken stone mineral aggregate is used, and they require a different type of bituminous material to obtain satisfactory results.

The gravel aggregate "road-mix" is a type of bituminous concrete, and, like it, depends upon density for stability and strength. This type of surface is proving to be popular throughout the country, and many ways of doing the work have been developed.

The gravel aggregate type is the least expensive, and several variations in the method of construction are used. Where the surface to be improved contains sufficient gravel, it is scarified to a depth of several inches, shaped up and the bituminous material applied. The mineral aggregate and bituminous material are then thoroughly mixed by continuous blading with either road machines or road drags. When this has been accomplished, the mixture is evenly spread and compacted with a roller weighing not less than 8 tons. Where there is some gravel in the surface, but not sufficient for the purpose, the old surface is scarified, fresh gravel added to provide the required depth, bituminous material applied, and the whole then mixed and shaped to the desired cross section. Where an entirely new surface is to be constructed, the roadbed is brought to the desired cross section parallel to and several inches below the finished grade of the road and fresh gravel spread thereon, shaped with road machines, and the bituminous material then applied. The bituminous material should be heated in the tank car and applied from a pressure distributor at a temperature of about 160° F. The total amount required for a surface 2 inches thick after rolling will be about $1\frac{3}{4}$ gallons per square yard. This should be put on in three applications of one-half gallon per square yard each, thorough blading and mixing following each application. A final seal coat of about one-fourth gallon per square yard should be applied after the surface has been rolled. Another variation of this method is to apply a prime coat of bituminous material to the subgrade before the gravel surfacing just described is spread. Where possible, this application of a prime coat to the subgrade is desirable, as it tends to prevent the poorer material in the base from being mixed in with the top course of gravel. Such surfaces should be not less than $1\frac{1}{2}$ inches in thickness nor more than 3 inches thick after rolling. Care should be exercised in selecting the gravel to be used, one being selected, if possible, with a continuous grading from fine to coarse, avoiding any gravel that is too sandy or that contains any appreciable amount of loam or clay. Some of either, or both, is generally found in most gravels, however, but the undesirable effects can be overcome by selection of a proper viscosity of the bituminous material. Either asphalt or tar can be used. The Department's specification No. 14-A is designed to cover tars suitable for this purpose, the specific viscosity being 45 to 55. With this tar the

finer should not ball up, and sufficient time should be afforded for proper mixing. The Department's specification No. 11-C covers the asphalt considered suitable. This specifies a 100 to 150 penetration asphalt cut back with naphtha, to which is added 10 per cent of kerosene by volume. The kerosene is needed to prevent the fines from balling and to retard the set until the mixing is completed, and the amount used with the asphalt should vary in accordance with the gravel requirements. Gravel aggregate surfaces are easily maintained if the proper grade of gravel and type of bituminous material has been used and thoroughly mixed. When such is necessary, however, it will be in the form of a surface treatment. Such a surface can be easily broken up and scarified later if more extensive repairs are required. Surfaces using a gravel aggregate are very satisfactory and permit of the maximum use of local material with a minimum of imported material. The costs here for this type of surface, 18 feet wide, run from \$2,000 to \$3,500 per mile.

The broken stone or macadam type of aggregate is, of course, stronger and more substantial than the gravel aggregate type of surface, being of the macadam type and depending principally upon the interlocking of the stone fragments for strength. It may be constructed in several ways, either by scarifying an existing broken stone surface and adding fresh stone to bring it to the required depth and cross section and then penetrating with the proper grade of bituminous material, mixing and shaping the whole with a road machine or road drag and rolling with a roller weighing not less than 8 tons, or by spreading a course of fresh stone upon the prepared subgrade. In this type of surface, as in the gravel aggregate, the use of the prime coat on the subgrade is desirable but not essential. The maintenance required is similar to that required by bituminous macadam, that is, eventually surface treatments. This type of surface costs more than the gravel aggregate, running in this State from \$4,000 to \$4,500 per mile.

As with the gravel aggregates, either tar or cut-back asphalts may be used. The tar is covered by Specification No. 14-A, a specific viscosity of from 55 to 65 being used. The cut-back is covered by Specification No. 11-B, which requires the same asphalt and naphtha mixed with 5 per cent of kerosene.

MUD PUMPS

One recent development in method and equipment now being used in some instances in other States, but as yet not used in Massachusetts, is a pump designed to force a mixture of water, earth and cement under cement-concrete slabs to restore them to grade. The method developed

is to drill holes in the cement-concrete surface and to force the mixture of water, loam and cement through the hole, the pressure developed being sufficient to raise the slab, and the cement eventually affording sufficient stability and strength to hold it there. As stated, the method has not been tried in this State. Although we occasionally experience slab settlement, there is not enough to warrant the purchase and use of the necessary equipment.

PERMANENT PATCHING

The application of the theory that maintenance requires a road surface to be kept always in as good condition as when constructed may be considered a recent development. This means that where cement concrete, bituminous macadam, bituminous concrete and other modern types of surfaces have failed, they must be patched with the same kind of surface. Early each year, therefore, maintenance crews provided with the necessary equipment start at the beginning of each route making permanent repairs to the surface. If it is a cement-concrete surface that has failed, the old surface is cut out with drills and replaced with quick setting cement concrete, travel being kept off for about forty-eight hours. If any particular defect in subgrade or drainage has been the cause of the failure, the defect is corrected before the surface is restored. Macadam and other surfaces are likewise cut out, the defects that may have caused the failure corrected, and the surface restored, rolled and immediately put into service.

SNOW REMOVAL

Economic considerations have long indicated the wisdom of making highways safely and conveniently available throughout the entire year. As a result the Massachusetts Department of Public Works was authorized about twelve years ago to assist the cities and towns in their work of clearing the highways of snow and ice. A few years ago the Department was further authorized to clear State highways by and at the expense of the State, so that today all of the State highway routes in this State are cleared by this Department. During the time that the Department has been so engaged, methods, organization and equipment have been developed.

When the work first started the Department used a fleet of $3\frac{1}{2}$ -ton, four-wheel drive trucks with single rear wheels and solid rubber tires, and several 10-ton tractors. Each truck was equipped with a 10-foot blade plow for routine work, and the tractors with wooden "V" plows

for emergency work. The trucks were loaned to the various towns to operate, but the tractors were operated by the Department. The aim then was to keep the roads open, and it was felt that excellent work had been accomplished by the towns if this were done. Today the work has developed to such an extent that in addition to the original fleet of $3\frac{1}{2}$ -ton, four-wheel drive trucks, the Department now owns and uses a fleet of $2\frac{1}{2}$, $3\frac{1}{2}$ and 5 ton four-wheel drive trucks equipped with pneumatic tires, dual rear, and 100 horse power motors. The power and traction of the new $2\frac{1}{2}$ -ton trucks are greater than that of the old $3\frac{1}{2}$ -ton trucks.

The new trucks are equipped with a variety of new type plows, each plow being intended for a particular phase of the work. In practice, blade plows are used for the routine work, the first cut being made with an 8-foot plow on a Ford or Chevrolet, and the second by a 10-foot plow on a $2\frac{1}{2}$ -ton truck. The windrow of snow thrown up by these two trucks is further pushed aside by a high moldboard plow of either the reversible or irreversible type mounted on a $2\frac{1}{2}$ -ton truck. When the accumulated snow to be pushed aside becomes greater than the high moldboard plow on the $2\frac{1}{2}$ -ton truck will handle, a $3\frac{1}{2}$ or 5 ton truck with a "V" plow and a wing is used. During intensive storms, when the "V" type plow and wing can no longer do the work, a rotary plow is used. Investigations into the power, traction, speed and draw bar pull of trucks are conducted in order to obtain those that will provide the maximum of each. A truck used to operate a rotary plow was recently equipped with a transmission that provides a gear reduction of 880 to 1. At an engine speed of 2,000 revolutions per minute this gives a speed forward of one revolution of the rear wheels in 28 seconds, or 0.26 mile per hour. With the development of the snow removal program, it was found that comparatively little trouble was experienced in clearing the highways, but that it became necessary to so remove the snow that the surfaces would be bare and clear almost immediately after the storm stopped. Packed snow and water from snow that melted during the day, all too frequently turns to ice at sundown, a condition that generally arises simultaneously on all highways throughout the State. This necessitates the application of sand mixed with calcium chloride. Hand spreading proved to be slow and difficult. Machine spreading, therefore, has been developed to such an extent that it is hoped by another year every truck owned by this Department used for the removal of snow will be equipped with a mechanical sand spreader as well as a plow. During the past several years it has cost the Department as much to sand icy places on the highways as to clear the snow.

TRAFFIC

One of the most interesting and important of the developments in the use of highways has been the introduction and application to our highway work of traffic studies. A knowledge of the use of highways as regards the number, type, origin and destination of vehicles, the speed at which they travel, and the manner in which they conduct themselves at intersections, is necessary in designing, constructing and maintaining highways, and is also necessary to intelligently provide such warning signs, guide signs and control as may be required. In the past, such information not being available, those who designed, constructed, maintained and operated highways made their decisions in accordance with their own views. Naturally, as these things were done in many different ways, some were well done and some were not so well done. Confusion existed as to what signs should be used and what they meant with respect to traffic warning, guidance and control. This situation having been recognized in Massachusetts some few years ago, a law was passed whereby the Department of Public Works was required to approve the various traffic provisions that cities and towns proposed to institute and use. To carry out the provisions of this act, the Department established a Traffic Engineering Division, and has issued three bulletins establishing standards covering the necessity and use of "Through Ways," "Traffic Control Signals," and "Warning and Guide Signs and Devices." The Traffic Engineering Division conducts traffic counts on the main numbered highways of this State and prepares a flow map, makes counts at particular intersections and on routes that are being studied for reconstruction or improvement, investigates the necessity for traffic control signals and "through ways" not only on the State highways but wherever any city or town desires to institute or install the same. A record by location on routes and intersections is kept of all accidents reported to the Registry, and is available for use whenever any study is being made of hazardous conditions. With the introduction of such traffic studies, guesswork is removed from all considerations involving highway design, use and operation.

WHITE LINES

The development of the use of the white lines may be considered of sufficient importance to be mentioned at this time. Originally white lines were used in this State on curves only, both vertical and horizontal. The lines were solid and were intended to act as a guide for the

motorists and to signify that he should keep to the right. Our surfaces at that time were of two lanes, some 15 feet in width, none more than 18 feet. With the introduction of the wider surfaces of three or four lanes, and greater speeds, white lines have been used more freely and have come to have additional meanings. Where the wider surfaces of today are marked into lanes during construction, as in cement-concrete surfaces and the dual types, white lines are ordinarily not needed. Where the surface is all of one type, however, it is generally necessary to designate the lanes as well as the center line. A solid white line is therefore used to designate the center line of the surface, and is used only where the motorists should not cross it. Broken white lines are used to designate lanes, and may be crossed wherever traffic conditions are such as to permit it being done in safety. Broken white lines are also used to define the extreme outer right edge of the surfaces. Motorists can guide themselves by such white lines by looking to their right, and thus avoid the necessity of looking into glaring headlights. It may be conceived that with the continued improvements in the alignment and grade of highways and the education of the public, the use of white lines on the right edge of the surface will come to replace the present center and lane lines.

ROADSIDES

In considering recent developments in the maintenance and use of highways, it appears from the results accomplished that the work being done by the Department on the roadsides of its highways should also be mentioned. It is not a new phase of the work, but the manner in which it is now being done and the results obtained are new. More than twenty years ago a man trained in selecting, planting and caring for trees was engaged by the Department to plant trees on the roadsides, but inasmuch as the real problem at that time was to construct highways, it was difficult for the engineers and the public to find much time or money for this phase of the work, so that it was conducted somewhat perfunctorily until about 1919, when this work was definitely placed in charge of an engineer whose duty it was to beautify our roadsides through planting, trimming and maintenance. The work has progressed so that today the facilities of the roadside organization are used not only in the maintenance of the highways but frequently in the design and construction. Studies are made sometimes, before a road is constructed, — generally during its construction, — of the plantings that are to be made when it is completed. Existing growth on the older roads is cut out, either to remove that which is unsightly, or to provide

vistas of distant lakes, valleys or other scenic beauties, or for safety where the vision is obstructed, such as on the inside of a curve. Trees are trimmed and, when necessary, repaired.

SELECTIVE TRIMMING

All trimming of underbrush is carefully supervised in order that suitable shrubs and plants will be left. All work done by public service corporations is inspected by a man from the roadside organization. Each year thousands of trees, vines and shrubs are planted to enhance the beauty, to hold a slope, or to mask an unsightly scar. A nursery is operated where all kinds of trees, shrubs and vines suitable for highway purposes are kept in stock. The progress today attained in this State in the construction of its highways now permits a response to the public demand for neatness and beauty along the roadsides. Also it has come to be realized that the surface is not the only part of the road; that the shoulders, the slopes and everything adjacent to the surface within the highway layout is also a part of the road, and that all should be in keeping. To this end the maintenance department endeavors to have neat, presentable and sightly roadsides. Dead trees, stumps, unsightly underbrush and the slashing of trees by public service corporations are no longer tolerated.

Discussion

MR. EDWIN R. OLIN: Perhaps Mr. Delano would be willing to give us some points as to the question of pedestrians upon State highways. Every man who drives a car has escaped hitting one with about one-nineteenth of a second to spare, and I notice it is a matter frequently taken up in the public press.

MR. DELANO: The construction of sidewalks has long been agitated for State highways, but the law has always been such that our responsibility has ceased at the curb line, and we were not permitted to construct them. A section in the recent Enabling Act permits us to construct sidewalks, if we see fit to do so. As a result, a great many sidewalks are being constructed where they are considered necessary, and where the towns will agree to maintain and keep them clear of stones and surface them if the Department or the town sees fit.

As to traffic control, our study for a traffic control signal includes the matter of pedestrian use of the intersection, and, if necessary, provision is made either for the signal automatically to appear or to be provided by the use of a push button.

QUESTION: May I ask Mr. Delano what is the anticipated life of these two new roads that are being built, and what it is going to cost to maintain them?

MR. DELANO: It is doubtful if anybody knows the life of these roads. We have in use roads with surfaces at least thirty years old, and they are in good condition. That being so, it is difficult to forecast how long a new type will last. Keeping in mind the subgrades and drainage provided, and the method of maintenance, they should last practically indefinitely.

One phase of use which makes it difficult to maintain a surface is the distortion caused by too heavy traffic on macadam. This is difficult to correct and eventually a new surface may be required. The cost is not very great. The cost of surfaces alone is apt to be greater during the first year or two of the life of a new road than during the next ten years.

QUESTION: What would this cost be, approximately?

MR. DELANO: From \$200 to \$250 a mile. The total average cost runs around \$800 a mile, but this includes everything — putting in new drainage, extending surfaces — a lot of betterments.

QUESTION: When you speak of a maintenance cost of \$200 or more per mile for a modern road, what proportion would be due to defects from a faulty base rather than to a faulty surface?

MR. DELANO: Practically none. On roads as constructed today we rarely get anything of that nature.

QUESTION: Is that true of the low cost asphalt surfacing such as the Cape roads?

MR. DELANO: It shouldn't be true, because in constructing low cost surfaces there naturally is justification in taking more of a chance with the base than with a high grade road. There may be a section where the base is suspected of being a little weak, but rather than build a more expensive surface, or even to rip out the suspected section, one would put the road in as designed.

QUESTION: The reason I asked that question is that a man in North Carolina told me that in using the low cost surface roads the maintenance was high the first year because of the necessity of correcting defective places, due to faults in the base not discovered in putting on the surface. The maintenance cost was considerably less the second year, and much less the third. I wondered if your experience had been the same.

MR. DELANO: Yes, about the same, except that I suppose in this State we are not likely to spend much money in surfacing a road where we know the base isn't right.

QUESTION: What is your experience with public service corporations in the cities and towns where underground structures have connections to be made? -

MR. DELANO: We have had a great deal of experience with public service corporations along that line. When the company desire to do any work of that nature within a State highway, a written application is made to the district office for permission, giving the necessary information as to what they want to do and where. An engineer then investigates that request with a representative of the company, and makes a report to the Boston office, with recommendations. The permit is ordinarily granted. It is a somewhat routine procedure and requires that the company which are doing the work shall replace that road in as good condition as they found it. If they disturb the surface they have to restore it to its original condition. Sometimes we find that trenches have settled a bit and must be brought up. Ordinarily we do not require the company to do it unless they become serious offenders in that respect. When settlements become too frequent we generally tighten up a little in our inspections and see that the tamping is done more carefully and the surface carefully put back.

QUESTION: What is the relation between cost and efficiency in using crib work as compared with the ordinary retaining wall?

MR. DELANO: Crib work costs considerably less. The concrete sections and the precast posts can be bought and delivered on the job, and they are very readily put in. It is efficient. There are quite a few sections of this type of wall on our State highways, and we will have more.

THE DESIGN OF CONCRETE FORM WORK

BY JOSEPH TUCKER *

(Presented at a meeting of the Designers Section of the Boston Society of Civil Engineers,
February 10, 1932)

WHEN building a reinforced concrete structure, the cost of form work constitutes a large item of expense, and therefore a great deal of consideration should be given to its economical design and construction.

Reinforced concrete structures are built universally. There are many contractors who specialize in this field, but from observation it would seem that very few of them have devoted their energies toward the economic manufacture and erection of forms.

I have been engaged in the form business since 1914, during which time I have been in contact with many contractors and am surprised to note that few of these contractors are really familiar with form costs. Time and again they are not able to discover that they have lost money on the forms until the job is completed.

Here are some of the reasons which I think are responsible for this condition:

1. Contractors use the same unit price for forms for a multiple story building as for a one story building. Analysis will disclose that this basis is erroneous. For example: A unit cost of 16 cents per square foot is used for manufacturing a set of forms; if these forms are to be used on a four story building, the cost charged against each square foot may be divided by 4, making the actual cost only 4 cents per square foot, because the forms are to be used four times. On the other hand, if this set of forms is used on a one story building, the cost is actually 16 cents per square foot. Again, considering erection, the first set-up is the most expensive, as it requires much time to get familiar with the general layout of the building; but if it is a multiple story structure, the men become more efficient as the job progresses, and the cost per square foot reduces constantly.

A set of forms should be used at least four times, for economic reasons. Of course, forms used more than four times will prove less costly; however, forms used less than four times will necessarily increase the cost per square foot.

* Treasurer, Tucker Concrete Form Company,

2. The material is ordered at random without giving study to the most practical lengths and widths for the particular job, the result being that, when the fabricating of the forms is completed, at least 20 per cent of the lumber is wasted, and the contractor has to go to the expense of carting the waste away.

3. The fabricating is left to the carpenter foreman on the job, who usually makes up the forms a little longer, and later cuts them to fit as he erects; this is due to lack of confidence or experience in designing them accurately before starting. He also does not take the trouble to see how the particular forms are to be re-used on the upper floors. For example: Column sides are generally reduced in widths and lengths, and so are beams and girders. The result is that when he starts re-using his forms on the upper floors he is obliged to discard the old set and build a substantial portion of another set to suit the new conditions. And it may be further noted that the carpenter foreman would be relieved of considerable responsibility if the contractor would make use of ready-made forms, so that the foreman could then devote his entire time to erection.

4. Thought is not given to the stripping of the forms and to access panels and clean-out holes. I have seen many jobs where forms had to be removed in order to clean out construction refuse, and where the carpenters would nail the forms as though they were to remain permanently.

Having these conditions in mind, I saw an opportunity for specializing in design, scheduling and making forms for concrete in a mill, centrally located, from which delivery to the job of the finished product could be made for erection, just as structural steel is fabricated and delivered for assembly.

Such a mill had to be conveniently placed on a large area of land which could also be used for storing lumber. It had to be equipped with the most modern sawmill machinery, and had to be operated by a corps of trained carpenters, who were able to read working drawings.

Successful fabrication of forms requires the assistance of experienced engineers who are familiar with the reinforced concrete construction, and who have a general knowledge of design and building, so that they may understand when and where slabs, beams or columns may be broken at a day's pouring without weakening the structure.

When a job to manufacture forms is procured, the next necessary step is for the form designer to go over the plans with the contractor, and together decide how many sets of forms are needed for the particular job. The number of sets of forms, of course, depends upon the season

of the year, the progress schedule, and the number of stories. This item being settled, the form designer determines which system of forms is best suited and which material is most fitted for the job.

We find that it is practical to design the forms by starting with the roof plan and working down through the several floors to the foundation walls. This is done for the purpose of eliminating as much of the remaking of the forms as is possible during the process of erection. For example: If a typical beam is 10 by 16 inches on the roof and 12 by 20 inches on the floor below, the beam bottom must have a reducing strip of 2 inches, and the beam sides a reducing strip of 4 inches. As a rule, columns diminish in size with multiple stories, and reducing strips must be provided. Shoring and bracing of the forms also have to be considered so that the shores and braces may be used again, from foundation walls to the floors and the roof, with the least amount of waste.

These fundamentals settled, the designer proceeds to draw key plans or setting plans and assemblies to determine the method of erection and stripping of the forms. He then begins building the job in the office on paper, and finds quite frequently that the architect or the engineer does not quite complete his details. Here the form designer proves to be an important link between the architect or engineer and the contractor on the job. Important details not shown on plans are ironed out long before the actual work begins, thereby preventing any unnecessary delays or expensive mistakes. The key plans are so thoroughly dimensioned that many times they are used as working drawings by the carpenter foreman, on the job.

At this point may I mention that the average architect or engineer gives very little consideration to form work when designing a reinforced concrete structure. I have found that a great deal of expense is added to the cost of building by lack of simplicity in its design. Where possible, uniform story heights should be selected, in order to prevent continual remaking of column forms, and frequent changes in column sizes should be avoided. Beam and girder sizes should be chosen which will be typical throughout the entire building, or at least on the same floor, even at the expense of a little extra concrete or reinforcing steel. Spacing of beams should also be studied for symmetry, and thickness of floors should be made constant, wherever possible, as changes in these conditions sometimes lead to many costly mistakes on the job.

By having a good-sized lumber yard connected with the mill, it is possible to buy lumber more economically at wholesale prices. Delivery in freight carloads at a siding in the yard is essential. Another saving may be procured by ordering lumber in random widths and lengths and

sorting the material into their respective piles, while being unloaded. By so doing the waste in lumber is reduced to approximately 2 per cent. Lumber should be piled conveniently in relation to the mill, so that there may be very little motion lost in handling the raw material into the mill.

Another saving by having forms manufactured at a plant such as this could be obtained in the following manner. When the forms are no longer needed on a job, they are hauled back to the yard and there reclaimed so that a substantial portion can be used on another job. This particular saving is passed along to the various contractors purchasing ready-made forms.

Our experience indicates that spruce is the best all-round material most suitable for concrete work, especially in New England, where we are very close to the source of supply. Spruce may be somewhat more expensive than hemlock or fir, but it has greater durability, and therefore can be used many more times. Boards that give best results must be fairly dry, milled one face, planed to uniform thickness, and edges rough. The reason for rough edges is that when the boards dry out, as they will, the fine grout fills the joints between the boards by adhering to the rough fibers of the edges, thus giving the panel a very smooth surface. Matched boards are sometimes mentioned in specifications. These may give the concrete a good surface at the first use, but after several uses will curl up at the matching, thereby giving the concrete a poorer appearance.

In the making of the forms for column sides, the use of $1\frac{1}{4}$ -inch stock dressed to $1\frac{1}{8}$ inches is recommended, even though it is a little heavier and more expensive. For beam bottoms 2-inch stock dressed to $1\frac{3}{4}$ inches should be used for reinforced concrete beams; and seven-eighths inch boards should be used for steel beams that are fireproofed. For floor panels and beam sides seven-eighths inch boards are used.

For bracing and supports, 3 by 4 inches has proven to be the most practical and economical stick; for instance, it is used as studs and rangers on the foundation walls, and later used in the superstructure as centering joists, posts and jacks. At the completion of the form work this material may be used by the mason for his staging. For girts, a 4 by 6 inch is commonly used; for column bracing, a 2 by 4 inch or 2 by 6 inch, depending upon the story heights; and for general tying and bracing, a rough 1 by 4 inch is used very generally.

When making forms it is a good practice to run the boards vertically in columns, curtain walls and very deep beams, especially on exterior work, as the joint marks in the concrete will be less noticeable

when sunlight strikes the surface. I have seen many good concrete jobs spoiled through lack of knowledge of this particular detail.

During the last five years several types of form material have been placed on the market with one particular idea in mind, namely, to give concrete a smooth surface with as few joints as possible. It has been my experience that too much finishing or rubbing on exterior concrete work has proven to be very unsatisfactory, due to change of climatic conditions in New England. I have noticed that frost tends to penetrate behind the thin coat of plaster or cement finish, and eventually causes it to crack and peel off.

To accomplish a smooth surface the steel form has been designed, but it is limited to walls and slabs. While steel forms have been fabricated and used for beams and rectangular columns, they have not proven practical nor economical, due to the inflexibility of the metal form to accommodate the different sizes required for columns and beams for various jobs. Several other types of forms have been manufactured for the purpose of giving a smooth surface to the concrete. In the Middle West a patented metal form giving the surface a pleasing architectural design has been used for ceilings with great success. Press-wood has been used as a lining or structural board. This material is useful for all types of form work and leaves a smooth surface; however, the cost of this material is at the present time prohibitive for use in this vicinity. Plywood or veneer has been used, but was found unsatisfactory, inasmuch as it cannot be used several times. This material cannot withstand much moisture, for it tends to curl when becoming damp.

Metal forms are adaptable for round columns, have been greatly improved, and are in use quite extensively.

Metal floor pans have been used quite extensively for long spans in concrete construction, and from a structural standpoint they are very practical, but from an architectural angle they have been found unsatisfactory, due to the uneven surface left by the pans. This condition can be corrected by building the pans out of press-wood, or by having a hung ceiling of metal lath and plaster.

Metal domes are used for two-way construction and are found economical for long spans. The main function is that they displace a considerable amount of concrete, therefore bringing lighter loads on to the footings.

My recommendation to the contractor using metal floor domes and pans is to build close centering where the engineer requires splay ends, cross ribs or bridging, and various other outlets and boxes for the mechanical trades. Close centering is also beneficial to the various mechan-

ics on the job, as it gives them a substantial footing upon which to work. However, open centering is economical when the building is designed very regularly.

There are many patented devices in the market for the erection and stripping of forms, such as column clamps, wall ties, adjustable shores, beam hangers, etc. Most of these devices are satisfactory and save time and labor, but it takes an experienced contractor to select the proper devices for his particular job.

Experience has taught us that it is most practical to oil the forms with a good grade of form oil for both wood and metal forms. It prevents concrete from adhering to the forms when they are being stripped. Forms should be oiled each time they are used. Oiling of wood forms also preserves the lumber and reduces shrinkage. The use of double-headed nails is economical, as it saves time in stripping and prevents breakage of the forms.

In designing forms, live loads should be considered as well as the dead load of the concrete. Forty pounds per square foot is a safe allowance for live loads. However, if concrete is shot into a hopper, which is placed in the center of the floor, the forms directly underneath must be reinforced to take care of this condition.

In vertical sections, such as columns and walls, a horizontal pressure will act upon the forms, due to the hydrostatic head of wet concrete. Tables showing location of walers and yokes have been compiled by concrete experts to aid the form designer. Thin walls or small columns should be poured slowly, as pressure depends largely on the speed at which the wall or column is being filled.

For calculating stresses in form lumber 1,200 pounds per square inch is allowed for bending, 200 pounds per square inch for horizontal shear, 350 pounds per square inch for bearing or crushing across the grain, and 1,200,000 pounds per square inch for the modulus of elasticity.

Our method of marking forms has been simplified to the *nth* degree. Floor panels are marked F; beam sides, B; beam bottoms, BB; column sides, C; wall panels, W; footing forms, Ft; bulkheads and boxes, Bk. Supporting members are marked as follows: Joists, J; Girts, G; Posts and Jacks, P; Studs, S; Rangers, R; and Braces, B, etc.

Two key plans are made for every floor and roof of the particular job, one showing floor panels, beam sides, beam bottoms, columns and wall panels; and the other plan showing the location and spacing of floor joists, posts, jacks and girts. Changes for additions or subtractions

required when remaking the forms on the upper floors are shown on the key plans for each respective floor level.

A schedule of material for each job is made and is carefully checked off as it is being loaded on to the truck. This facilitates the handling of the forms on the job. When the forms land on the job it is very important to have an intelligent man in charge of unloading and sorting the material, according to our key plans. This man should be able to read blueprints. I have found from experience that such a man is a great asset to the contractor, as his duties are fully as important as the foreman carpenter. With the present high cost of labor, the carpenter erecting the forms should at no time have to look for any panel, but should find the particular piece right where the work requires it to be.

Standardizing form making is purely an engineering problem. It has been our aim to bring the contractor to a serious realization of this fact, and in conclusion will say that it is the function of the engineer to do the planning, whereas the craftsman is to do the making.

OF GENERAL INTEREST

MEMOIRS

William Fish Williams*

DIED OCTOBER 1, 1929

WILLIAM FISH WILLIAMS, the son of Capt. Thomas W. and Eliza Azelia (Griswold) Williams, was born on the whaling ship, "Florida", in the South Pacific Ocean, somewhere between Tasmania and New Zealand, on January 12, 1859, in a howling gale of wind. The first seven years of his life were passed aboard the various vessels of which his father was master, accompanied by his mother and a younger sister, who was also born at sea.

He received his early education in the schools of Oakland and San Francisco, California. He was graduated from Columbia University, New York, N. Y., in 1881, with the degree of Civil Engineer, and, in 1882, with that of Mining Engineer.

During 1883 Mr. Williams was engaged in examining mines in Colorado, Utah and California, and the years from 1884 to 1888 were spent in private practice as a Civil Engineer in Connecticut. From 1890 to 1893 he served as chief engineer of Cumberland Lands, Limited, in Stewart County, Tennessee,

a property of 46,000 acres of farming, timber and mineral lands. His work during this period included a survey of the entire property, laying out of town sites, and the location of fifteen miles of railroad, as well as designs for the mechanical work of the plant.

From 1893 to 1912 he filled the office of city engineer of New Bedford, Massachusetts, during which time he represented the city as engineer in supervising the elimination of railroad grade crossings in that municipality. Mr. Williams likewise served as chief engineer of the Fairhaven bridge, constructed under his direction at a cost of \$1,250,000. The intercepting sewer system was also under his direction for two years after he went to the State House.

In 1912 he was appointed chief engineer of the Massachusetts Board of Harbor and Land Commissioners, and later, as engineer of waterways and public lands. During this period Mr. Williams represented the State of Massachusetts in connection with the construction of the Cape Cod Canal. He also conducted a survey and reported upon the water and power resources of the State.

In 1920, when the Massachusetts Commission of Public Works was created, Mr. Williams was appointed its bridge engineer, and remained in that

* Memoir prepared by Charles R. Gow and James W. Rollins, Jr., Members, Am. Soc. C. E., and B. S. C. E.

capacity until December 6, 1922. At this time he was selected by Governor Cox as chairman of the Commission, in which capacity he directed all State highway construction, including the operations of the Registry of Motor Vehicles, and, in addition, supervised the administration of all State-owned harbor facilities and such construction as was connected therewith. In this position he assumed responsible charge of an annual expenditure approximating \$15,000,000. His administration of this important office was marked by an utter absence of any public criticism and a pronounced improvement in efficiency of operation. He retired from this office on December 25, 1928, having attained the legal age limit of seventy years.

After his retirement from public office Mr. Williams was engaged by the Commonwealth to advise and represent the State in connection with a legislative measure for the abolition of railroad grade crossings. He was similarly employed in a consulting capacity to advise the Commission to Investigate Pollution of Boston Harbor, as well as a commission appointed to report upon the filling in of a portion of Fort Point Channel and South Bay in Boston.

As a public official Mr. Williams was an ideal representative. He was not only an eminent engineer; he possessed to an unusual degree the attribute of sound common sense, and, in addition, displayed rare executive ability, which combination resulted in a high standard of efficiency in the conduct of his office. He won the respect and complete confidence of the many State, county, and municipal officials with whom he had to deal. He was at his best when appearing before the several legislative committees having jurisdiction over matters affecting his Department. So impressed were they with his judgment that he once said, "No bill affecting my

Department which I opposed ever passed the Legislature during my term of office."

Mr. Williams was a man of unusually attractive personality and friendly persuasiveness. Always a thorough gentleman under every circumstance, he was able to meet and overcome trying situations by virtue of his calmness, poise, patience and understanding of human nature. His logic was as invariably sound and clear as his arguments were convincing. He was uniformly popular alike with superiors, associates and subordinates. His judgment was exceptionally keen and extended into a wide variety of fields other than that of his chosen profession.

He was a delightful companion, taking always a loving, living interest in his fellow men and maintaining a broad outlook upon life. His early years had been filled with adventure, and his reminiscences of those experiences recited in his customary modest and lucid style invariably captivated his listeners. Mr. Williams numbered among his intimates men from every walk of life, including many of the leading citizens of his State. He was a most welcome guest at the firesides of his host of friends who loved and sought his companionship.

He was a distinguished member of the engineering profession for almost fifty years without a single blemish on his record. His keen powers of analysis permitted him to render wise decisions respecting problems with which often he had enjoyed little previous experience. He possessed the rare faculty of developing the facts clearly and of drawing sound conclusions from them. His opinion was widely sought by his fellow engineers because of this unusual gift.

Mr. Williams maintained constantly a rigid standard of professional ethics. He invariably held himself aloof from controversy and endeavored to harmo-

nize conflicting opinions. He steadfastly refused to deviate from the paths of duty as he saw them, even to favor a personal friend. He stood loyally by his superiors whenever put to the test, and no official was ever embarrassed, even in the slightest degree, by any action or statement of his. He was an inspiration to all who were fortunate enough to be associated with him in his work, and his example might well be emulated by the younger generation of present-day engineers.

He died suddenly on October 1, 1929. His passing leaves a void in the hearts of many who knew him and who had learned to love him for his personal qualities. The estimate of his oldest friend is —

A noble soul has lived, stamped its mark on the world, and gone, but its record will live, and the love and admiration we have for him will last beyond life's closing day. For more than sixty years I have been his friend and confidant. During that long period we have never had an unpleasant word. I have never known him to have an ignoble thought or do a wrong act. He was loyal, faithful and true to himself, his friends and his duty.

Mr. Williams was married to Anna L. Cornor on April 7, 1883. He is survived by two sons, Thomas W. Williams, Assoc. M. Am. Soc. C. E., of New Bedford, and Harold Williams of Pelham, New York; and two daughters, Mrs. F. W. Oesting, Jr., of New Bedford, and Mrs. James M. Buchanan of Maplewood, New Jersey. A sister, Mrs. Edgar R. Lewis, of Prosser, Washington, also survives him.

Mr. Williams was elected a Member of the Boston Society of Civil Engineers on April 18, 1894. He was also a member of the American Society of Civil Engineers.

Clemens Herschel*

DIED MARCH 1, 1930

CLEMENS HERSCHEL was born on March 23, 1842. He passed his boyhood in Davenport, Iowa, and, after studying with a tutor he entered the Lawrence Scientific School of Harvard University at the early age of sixteen. Graduating in 1860 with distinction (*summa cum laude*), he took an advanced course in chemistry for one term, and then went to Europe to study French and prepare to enter the École des Ponts et Chaussées, in Paris. As the number of foreigners was limited, and the quota was complete, he was unable to obtain admission, and went, as a consequence, to the Technical School at Karlsruhe, Germany, to complete his education. Long afterward, in 1925, the Karlsruhe Technical School bestowed upon him the honorary title of Doctor of Engineering.

In 1864 Mr. Herschel returned to the United States and opened an office as consulting engineer, in Boston, Massachusetts, doing such work as came to hand. He was engineer of the Albany Street bridge, built by the city of Boston in 1867, and at one time was connected with the Boston sewer department. The variety of his work is indicated by a letterhead of 1871, which reads, "Civil Engineering in all its branches, Iron and other Bridges and Roofs, Hydraulic Engineering, Roads, River and Harbor Improvements, etc., etc." In 1872 he was appointed superintendent of streets of West Roxbury, Massachusetts (now part of Boston), and from 1881 to 1883 he was one of the three Railroad Commissioners of Massachusetts.

Mr. Herschel was engineer of the Quinnipiac drawbridge, New Haven, Connecticut, erected 1874-1878, and

* Memoir prepared by J. Waldo Smith, Hon. M. Am. Soc. C. E., M. B. S. C. E. and William H. Burr, M. Am. Soc. C. E.

this led to the publication, in 1875, of his book on "Continuous Revolving Drawbridges." A bridge of minor importance, but which is of interest because it is still standing and readily accessible, is that across the Public Garden Pond in Boston. The design, prepared in co-operation with an architect named William G. Preston, was accepted as the result of a prize competition.

To one of Mr. Herschel's independence of thought it was disappointing to note that "bridges and roofs" did not offer any future for a consulting engineer, since their design was falling entirely into the hands of large bridge companies, where a designer became, as he expressed it, merely a "cog in a wheel." He had at one time worked under the late James B. Francis, Past President and Hon. M. Am. Soc. C. E., a hydraulic engineer whom he greatly admired, and this, as well as the lack of a future in bridge work, naturally turned his attention especially to hydraulics.

In 1879 Mr. Herschel was appointed hydraulic engineer of the Holyoke (Massachusetts) Water Power Company. It should be remembered that power at Holyoke was developed before the days of electrical transmission, and the Power Company not only controlled the dam, but had also to operate the canals which supplied water for power to the various mills. During the ten years that Mr. Herschel held this position he built and operated the Holyoke Testing Flume, then one of the few places in the country for measuring the efficiency of hydraulic turbines. All the turbines in use in the Holyoke mills were tested, and the discharge was determined for different gate-openings. Thus, every turbine became its own water meter, and by reading the gate-openings twice a day, an accurate record of the use of water for power

purposes was obtained. This system was of great help in securing an equitable distribution of water among the different mills, supplied from the canals of the Holyoke Water Power Company, and in preventing waste.

This was not enough. The many paper mills used large quantities of wash water that did not pass through the turbines and was not measured. Mr. Herschel gazed on those wash-water pipes and pondered. He wondered how they could be made to tell how much water was passing through them. The Venturi meter was the answer, but it came too late to be used for measuring wash water. As he was wont to remark, the Venturi meter has been used for a great variety of purposes, but never for the purpose for which it was invented.

It had been observed by Venturi, in 1791, that if a liquid flows first through a converging and then through a diverging cone, the pressure at the narrow section where the two cones join is less than the initial pressure. To Venturi, the philosopher, this was merely an interesting phenomenon of Nature; to Herschel it was a suggestion of a practical and much needed device, and, in 1887, he conducted a series of tests to determine whether the rate of flow could be calculated from this difference in pressure. Here, again, his training under Mr. Francis was of great assistance, as the latter had determined in tests on diverging cones the small taper necessary for the down-stream cone of the meter, if the permanent or over-all loss of head should be a minimum.

The Holyoke tests were so satisfactory that the device was patented and was named the Venturi meter. Thus, Clemens Herschel became "the man who made Venturi famous." He was presented with the Rowland Prize by the Society for his paper describing

his tests,* and was awarded the Elliott Cresson Gold Medal by the Franklin Institute for his invention.†

Another piece of important work at Holyoke was in practically rebuilding the wooden dam across the Connecticut River. This had become unsafe and threatened to give way, but when repaired and filled with gravel it lasted as long as necessary, that is, until it was replaced, after Mr. Herschel left Holyoke, by a stone dam built below it. In connection with the work on the dam Mr. Herschel added to the diversity of his accomplishments by going down in a diving suit, because he did not believe what the divers told him and he wanted to see for himself.

In 1889 Mr. Herschel was made chief engineer and superintendent of the East Jersey Water Company, and gave up his position with the Holyoke Water Power Company. The East Jersey Water Company was organized to build works to provide a large additional water supply to Newark and other New Jersey communities. These works included dams and reservoirs on the Pequannock River, and a riveted, steel pipe line which was one of the first of that type to be built in the East. A contract was made on September 24, 1889, with the city of Newark, to build works to supply 50,000,000 gallons of water per day to that city, the works to be finished by May 1, 1892. Eventually, two pipe lines were laid and the capacity was increased to 80,000,000 gallons.

It was on the works of the East Jersey Water Company that the Venturi meter had its first practical application. About thirteen meters were used, and a daily record was kept of all water entering the pipes and of water delivered. From this beginning the use of the Venturi meter has spread over the entire

world, not only for water, but also for measuring gas and steam and other fluids. Noteworthy on account of their great size are the meters of the Catskill Aqueduct, which measure the water consumption of New York City.

It was during Mr. Herschel's service with the East Jersey Water Company that he published, in 1897, "115 Hydraulic Experiments," on the flow of water in pipes and conduits. He left that company in 1900, after the works for the city of Newark had been finished and turned over to the city.

Since 1884 Mr. Herschel had been consulting engineer of the largest power developments at Niagara Falls, including the work of the Cataract Construction Company and the Niagara Falls Power Company. In earlier developments at Niagara Falls the head was subdivided or part wasted, and power was distributed by shafting. The ready-made turbines available at that time in the United States could not be used for the high heads and the large volumes of water available at Niagara Falls, and electrical transmission of power seemed desirable. To consider these questions, an International Commission of five members was appointed, Mr. Herschel being the only American member.

This work brought him into contact with European and especially with Swiss builders of hydraulic turbines, and the decision was reached to obtain from Europe turbines built to order for the head and discharge available, and with a speed suitable for driving electric generators.

Turbines were first imported from Switzerland about 1904, but later the building of large power hydraulic turbines designed for predetermined conditions was established in the United States, largely as a result of the experience of the Niagara Falls Power

* Transactions, Am. Soc. C. E., Vol. XVII (July-December, 1887), p. 228.

† Proceedings, Franklin Institute, February, 1899.

Company with Swiss turbines. Mr. Herschel was the first manager of the Hydraulic Engineering Department of the Allis-Chalmers Company, but resigned when the company's office was moved from New York to Milwaukee, Wisconsin. With his intense love for Boston, he considered even New York as "too far west," and Milwaukee was unthinkable.

Mr. Herschel devised an application of the Venturi meter, which he called a "fall increaser," to increase the power of hydraulic turbines when low head was experienced in times of flood. This, however, was never put into practice, and conical draft-tubes, and other features of more recent turbine design, have rendered it unnecessary.

Mr. Herschel continued to act as consulting engineer, with his office at 2 Wall Street, New York. He was one of a commission of three engineers who examined the plans for the New York City Aqueduct in 1910, before they were approved by the Board of Estimate and Apportionment. In 1920 he read a paper before the American Society of Mechanical Engineers on "An Improved Form of Weir for Gaging in Open Channels," in which he described a method of reading pressures in a perforated pipe placed at the crest of the weir, and of calculating the flow from these readings.

He was a frequent contributor to the technical journals, and was always ready to champion the Venturi meter with vigor. Although he had written "A Farewell Word on the Venturi Meter," in April, 1929, at the age of eighty-seven, we find him back again on the firing line with a letter* to the editor of "Engineering News-Record," written when confined to his home, and dated "Glen Ridge, N. J., August 28, 1929."

Among the obviously professional parts of Mr. Herschel's engineering career there is none more prominent

than his contributions to what may be called engineering science. It was fundamental with him in seeking the solution of any important engineering problem to make a searching general analysis of all its features leading to results constituting a marked advance in engineering practice. His professional work from its beginning to its end exhibited such marked advances as in his papers on drawbridges and other continuous trusses and on the Venturi meter, and in other cases of similar character. The same desire to give intellectual quality and finish to his professional work is gracefully shown in his translation of Frontinus on the water supply of Ancient Rome.

These characteristics of his practice as a civil engineer just at the time when civil engineering was taking its place as a profession in the United States made him one of its marked pioneers, especially in hydraulic engineering. His excellent educational equipment combined with a trained analytic mind was well timed to act upon the opportunities offered by the profession of civil engineering then coming into being. In fact, it is due to him and a few others associated with him that hydraulic engineering has been developed to its present status in this country.

His most remarkable literary achievement, and the culmination of years of study, was the publication, in 1899, of a translation from the Latin into English of the "Two Books on the Water Supply of the City of Rome," by Sextus Julius Frontinus. Like many another, Mr. Herschel had forgotten the Latin learned in his youth, but, nothing daunted, he undertook the task with the help of a French and a German translation, and produced the first translation to appear in English.

Mr. Herschel enjoyed unusually good health until the last year of his life, and

* Engineering News-Record, September 12, 1929.

commuted daily from Glen Ridge, New Jersey, to his office in New York.

He was married, in 1869, to Grace D. Hobart of Boston, who died in 1898; he was married a second time, in 1910, to Jeanette B. Hunter of Thompsonville, Connecticut. His children, all of whom survive, are Arthur H., Winslow H., and Clementine (Mrs. Hobart Rawson), by his first wife, and one son, Clemens, by his second wife.

Mr. Herschel was Treasurer of the Boston Society of Civil Engineers from 1874 to 1880, and was President of that Society in 1890-1891. At the time of his death he was Past President and Honorary Member both of the American and of the Boston Society of Civil Engineers. He always loved Boston and the Boston Society, and directed in his will that his engineering books should be given to the Boston Society and to the Boston Public Library. His correspondence of many years has been given to the Engineering School of Harvard University.

In addition to the memberships mentioned, Mr. Herschel was a member of the Union Club of Boston, the Century and Engineers' Clubs of New York City, and a Life Member of the Institution of Civil Engineers of London, England.

Mr. Herschel was elected a Member of the Boston Society of Civil Engineers on June 8, 1874, and an Honorary Member on March 5, 1915.

Hector James Hughes*

DIED MARCH 1, 1930

HECTOR JAMES HUGHES was born on October 23, 1871, at Centralia, Pennsylvania. His parents were James H. and Mary (Miller) Hughes. He was prepared for college partly at the public schools of Williamsport, Pennsylvania, partly by a tutor, and partly

by his private studies. For more than two years before entering Harvard College he worked as a clerk. His studies, which gave no indication of his coming career, were mainly the classics, German, French, English, history and economics. In 1894, when he was graduated from Harvard College with the degree of Bachelor of Arts, he received honorable mention in the last named subjects.

Immediately following his graduation Mr. Hughes accepted a position as a rodman in the office of the chief engineer of the town of Brookline, Massachusetts. He worked in this capacity until the fall of 1897, by which time he was entirely sure of his profession, for he then registered in the Lawrence Scientific School of Harvard University as a third-year student in civil engineering, receiving the degree of Bachelor of Science in 1899. He also served as assistant in mechanics in 1898 and 1899. He then accepted a position in the office of the chief engineer of the Chicago, Burlington & Quincy Railroad Company, in Chicago, Illinois, and, in 1900, was assigned to take charge of certain pieces of construction work in Iowa. From April to August, 1902, he was employed by the American Bridge Company, at Pittsburgh, Pennsylvania.

In the fall of 1902 Mr. Hughes was appointed instructor in hydraulics at Harvard University, and from that time made Cambridge, Massachusetts, his home. His successive appointments in his chosen field were as assistant professor of hydraulics and sanitary engineering, 1903 to 1908; assistant professor of civil engineering, 1908 to 1913; associate professor of civil engineering, 1913 and 1914; and professor of civil engineering, 1914 to 1930. From September, 1906, to 1911, in addition to his teaching, Professor Hughes was a

* Memoir prepared by Theodore Reed Kendall, M. Am. Soc. C. E., M. B. S. C. E.

member of the firm of Burke & Hughes, consulting engineers, of Cambridge.

Professor Hughes' contributions to the science of engineering include "A Treatise on Hydraulics" (with A. T. Safford, M. Am. Soc. C. E.), "Roads and Toll Roads in America," "Highway Engineering Education," and two articles on roads for the *Cyclopædia of American Government*. He was a member of many scientific bodies, including the American Society of Civil Engineers, the American Society for Testing Materials, the International Navigation Congress, the Society for the Promotion of Engineering Education, the American Society of Civil Engineers, the National Association of State Highway Officials, the American Society for Municipal Improvements, and the American Road Builders Association. He was also a Fellow of the American Association for the Advancement of Science, a member of the American Academy of Arts and Sciences, and the Harvard Engineering Society. He was a member of the Harvard Club of Boston, Massachusetts, of the Oakley Country Club, Belmont, Massachusetts, the Woods Hole Golf Club, at Woods Hole, Massachusetts, and the Kittanett Club, Marion, Massachusetts.

Professor Hughes was a regular attendant at the annual meetings of the Society and made frequent trips to New York City to attend the meetings and the annual dinners of the Harvard Engineering Society, in the development of which he showed constant interest.

Hector James Hughes was distinguished chiefly as an administrative officer. His executive capacity was first evidenced by the conspicuous success of his administration of the Harvard Engineering Camp, at Squam Lake, New Hampshire. This led to his appointment as its director in 1909, an appointment which he held until the close of his life. The many students

who subjected themselves to the hard work and rigid discipline of the camp look back with satisfaction on that experience.

During the life of the co-operative agreement between Harvard University and the Massachusetts Institute of Technology, Professor Hughes, with other Harvard professors, gave instruction at the Institute. On the establishment of the Harvard Engineering School, in 1919, he was appointed chairman of the Administrative Board, and, in 1920, was appointed dean of the school. He held this appointment until his death.

The record of Hector James Hughes as dean is one of faithful devotion, of sanity, and of clarity of mind in meeting the problems of re-establishing and developing the Harvard Engineering School; of a quiet insistence on the maintenance of the highest ideals in the work of the school; of firmness, understanding and sympathy in his relations with students; and of unfailing helpfulness in his contacts with his colleagues.

On April 15, 1902, he was married to Elinor Lambert of Cambridge, who, with their two daughters, Katharine Porter and Elinor Lambert, survives him.

The following appreciation of Professor Hughes appeared in the Harvard Engineering Society Bulletin for April, 1930:

A Soldier has gone West.

He might have spared himself and enjoyed his one recreation—golf—and remained with us for a score of years, but that was not his way. He stayed at his post until it was too late to reinforce his ebbing strength.

Few of us have known the real Hector James Hughes until the last few years when we began to realize the burdens he had assumed. It was his aim to relieve the other members of the Faculty as much as possible of all ad-

ministrative work, taking unto himself those labors that the staff might give itself unstintingly to teaching. We know that the success of the Harvard Engineering School is in large measure due to Dean Hughes' administrative zeal.

Dean Hughes' memory will stand as a guiding beacon to all Harvard engineers, an example of determination and faithful performance of duty as he saw it.

The Harvard Alumni Bulletin of March 13, 1930, carried the following words of appreciation:

In the death of Dean Hughes, the University has lost a leader whose guiding hand was greatly needed in the further development of its instruction in engineering. Of the personal bereavement his passing brings to friends and colleagues in the University and the profession, this is not the place to speak at length. There was in him a kind of honest sweetness, a slightly quizzical kindliness and faithfulness in the performance of the day's work, that endeared him to all with whom he came into continued contact. He took his tasks and problems seriously and brought to them great clarity of mind and an essential common sense; but he had in him nothing of the showman or the propagandist. His was a leadership that was especially of value under the circumstances which have attended the growth of the Engineering School since 1920.

The task he faced [in reorganizing the Harvard Engineering School after 1918] had in it unusual elements of difficulty. A great co-operative plan had been abandoned because of legal difficulty under the McKay bequest. The Engineering School was thrust back into the University as an undergraduate department, and it had to find itself anew. The Dean had to reunite the Faculty that had been merged for a time into a larger and more complex organization and thus in part disrupted.

The business of building technical curricula for undergraduates and yet maintaining close connections with Harvard College had to be safely and expeditiously accomplished. There were courses to be organized, men to seek, machinery to set up and rehabilitate, and students to attract without a falling off in standards. The McKay endowment gave to the school the promise rather than the reality of affluence. The whole enterprise had to be reconceived, established on a permanent and satisfactory basis, and made to commend itself by its results.

Into the complexities of this situation Dean Hughes brought a patient, painstaking, experimental industry. The school made no dramatic moves, but it went forward quietly, steadily and continuously. It faces now its greatest problem. Just as Harvard College was taking on a new character under the house plan, with resulting perplexities as to the disposition of the undergraduates in engineering, the school has been robbed of a leader who had won affection, respect and confidence in every quarter. It is hard to estimate the debt it owes to his watchfulness and insight.

Professor Hughes was elected a Member of the Boston Society of Civil Engineers on April 15, 1903.

Allen Hazen*

DIED JULY 26, 1930

ALLEN HAZEN, the son of Charles Dana and Abbie (Coleman) Hazen, was born in Hartford, Vermont, on August 28, 1869. He attended the schools of his native town and the New Hampshire College of Agriculture and Mechanic Arts, from which he was graduated in 1885.

After completing a special course in sanitary chemistry at the Massachusetts Institute of Technology, in 1888, Mr. Hazen was appointed, on the

* Memoir prepared by George W. Fuller, M. Am. Soc. C. E., M. B. S. C. E.

recommendation of Dr. T. M. Drown, then chief chemist of the Massachusetts State Board of Health, to take charge of the Board's Experiment Station at Lawrence, Massachusetts. The Lawrence investigations were a classic pioneering work in the methods of purification of water and sewage from a combined engineering, chemical and biological viewpoint, and did much to direct attention to and confirm the germ theory of disease. With numerous severe epidemics of typhoid fever, this was a critical period in the development of improved water supplies for cities in the United States.

While Mr. Hazen was at Lawrence an epidemic of Asiatic cholera occurred at Hamburg, Germany, and the American public was much disturbed by the appearance of that disease on ships in New York Harbor. Under these stimulating circumstances, the investigations at Lawrence were continued and included extensive studies by Mr. Hazen of methods of measuring the physical properties of sands, gravels and other materials, and of comparing their suitability for practical use in water or sewage filters. Widespread attention was given to the data of the Lawrence Station which was installed initially to demonstrate the feasibility of disposing of the sewage from the North Metropolitan Sewerage District of Boston on the Saugus marshes, or otherwise by "land treatment." In fact, the Lawrence results, as contained in the State Board of Health reports for several years beginning in 1890, were regarded as epoch-making in establishing this branch of sanitary science on a sound modern basis; and this view was shared throughout the world, not only by engineers, but by medical health officers and laboratory workers in various fields.

In the design and supervision of construction of the intermittent sand filter for the Lawrence water supply, drawn

from the polluted Merrimack River, the late Hiram F. Mills, Hon. M. Am. Soc. C. E., Engineer Member of the Massachusetts State Board of Health, who was assisted in that work by Mr. Hazen, availed himself of various studies and practical tests at the experiment station. In fact, the methods of mechanical analysis of sand developed by Mr. Hazen were at once adopted by engineers as standard, and have been used almost exclusively since then.

Mr. Hazen's next work was at the World's Fair in Chicago, Illinois, in 1893, where he was in charge of the disposal of sewage at the Fair grounds. Following this service he spent a year in Europe in travel and study, including courses in hydraulics and structures at the Dresden Polytechnic Institute.

Soon afterward he entered private engineering practice in Boston, Massachusetts, with the late Albert F. Noyes, M. Am. Soc. C. E., under the firm name of Noyes & Hazen. After Mr. Noyes' death, in 1896, Mr. Hazen transferred his offices to New York City, and, in 1897, was engaged in the design and construction of the water filter plant at Albany, New York, the first modern, continuously operating, slow-sand filter plant in the United States.

In 1904 Mr. Hazen formed a partnership with the late George C. Whipple, M. Am. Soc. C. E., which continued until Professor Whipple's death in 1924. In later years there were associated with him, in this engineering practice, Weston E. Fuller, Malcolm Pirnie and Chester M. Everett, Members, Am. Soc. C. E., and Mr. L. N. Babbitt.

While in early years water purification was a major item in the practice of the firm, its activities related to all branches of engineering in the fields of water supply and water distribution, especially dams and large pipe lines, as well as valuation work for rate-making and municipal acquisition. Mr. Hazen

served a large number of the prominent water departments and water companies in various parts of North America. In 1906 he advised the Water Department of Brisbane, Queensland, Australia.

He was particularly interested in hydraulics and in hydrography, and, in addition to writing many papers on sanitary subjects, made a number of valuable and practical contributions to engineering literature on the subject of run-off of streams. He also wrote several books on subjects of interest to waterworks engineers and officials, including "Filtration of Public Water Supplies," "Clean Water and How to Get It," "Meter Rates for Water Works," and "Flood Flows," published in 1930. In collaboration with Gardner S. Williams, M. Am. Soc. C. E., he compiled a volume of "Hydraulic Tables," a book which is in extensive use. He was also editor of the Water Supply Section of the American Civil Engineer's Pocket Book.

He was very active in the affairs of the American Society of Civil Engineers, and frequently contributed papers and discussions to its publications. In 1900 he received the Thomas Fitch Rowland Prize for his paper entitled "The Albany Water Filtration Plant,"* and in 1915 the Norman Medal was awarded to him for his paper entitled "Storage to Be Provided in Impounding Reservoirs for Municipal Water Supply."† He also represented the Society on various committees, several of which are included in the following: Special Committee to Codify Present Practice on the Bearing Value of Soils for Foundations (1916-1926); Joint Committee of Founder Societies Finance Committee on Joint Activities (1926-1927); Vice-Chairman, Executive Committee of the Board of Direction (1927); Honorary Membership Committee (1927); Com-

mittee on Soils (1928-1929); National Research Council (1930); and Committee on Dams (1930).

Mr. Hazen was a thorough student who acquainted himself personally with the various details of all his problems. He applied to them an unusually clear insight, and thus drew conclusions quickly and with precision. He had a remarkable aptitude for clear and concise statement, both in speech and in writing, to which he added exceptional skill in putting the results of his investigations into simple and practical form so that others could readily make use of them.

The influence of Allen Hazen's leadership in advancing waterworks practice during his engineering day and age was unquestionably great. That leadership was due largely to his unusual capacity for clear, straight thinking on all major elements of an engineering proposition, and to a dominating personality. In whatever he undertook he was practical, sound, progressive, constructive and tenacious. In his death from heart disease at Miles City, Montana, while taking a combined pleasure and business trip in the West, America lost one of its greatest engineers.

Mr. Hazen was an Honorary Member of the American Water Works Association. He was also a member of many engineering and technical societies in the United States, Canada, England and France. He received honorary degrees of Doctor of Science from New Hampshire College in 1913 and from Dartmouth College in 1917.

In 1902 he was married to Elizabeth McConway, the daughter of William McConway, one of the leading citizens of Pittsburgh, Pennsylvania. He is survived by Mrs. Hazen, four daughters, and two sons.

* Transactions, Am. Soc. C. E., Vol. XLIII (June, 1900), p. 244.

† *Loc. cit.*, Vol. LXXVII (December, 1914), p. 1539.

At its meeting on September 29, 1930, the Board of Direction of the American Society of Civil Engineers adopted the following resolution:

In the death of Allen Hazen the engineering profession has lost a distinguished member who gave generously of his time and energy in its advancement.

During his thirty-four years of membership in the American Society of Civil Engineers Mr. Hazen served as director for three years, as vice-president for two years, and on many important committees:

The Board of Direction, cognizant of his loyal and active interest in the

affairs of the Society, his contributions to technical literature, and his exemplification of the highest ethical standards, desires to place on record its appreciation of his services and to pay tribute to his qualities and attainments as a man and an engineer.

The Board hereby records its deep regret at the loss of Mr. Hazen, and extends its sincere sympathy to the members of his family.

Mr. Hazen was elected a Member of the Boston Society of Civil Engineers on December 19, 1894.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

APRIL 20, 1932. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order by the President, Ralph W. Horne. There were about 90 members and guests present. Previous to this meeting 55 members attended the usual buffet supper.

The President announced the death of the following members: Herbert C. Daggett, died March 17, 1932, member since April 20, 1927; Charles L. Edgar, died April 14, 1932, member since January 27, 1915; Elwyn L. Russell, died March 20, 1932, member since December 20, 1922; Edward S. Smilie, died March 21, 1932, member since April 18, 1883.

The Secretary announced that the following had been elected to membership:

Grade of Member: William L. Hyland, Erling Albert Hanson,* John O. Harmaala,* John Joseph Vertic.*

Grade of Junior: Nathan N. Drucker.

The President presented the matter of proposed amendments to the Constitution to provide for the grade of Student Members. The proposed amendments to the

Constitution are as follows, and are indicated by italics:

AMENDMENTS TO CONSTITUTION

PROPOSED READING

Article II. Membership

The Society shall consist of Members, Honorary Members, Juniors, *Students* and Associates.

Juniors shall be not less than eighteen years nor more than twenty-five years of age, and their connection with the Society shall cease when they become twenty-six years of age, unless they be previously transferred to another grade. They shall be in active practice in some branch of engineering, or other technical profession, or graduates from a school of engineering of recognized standing. *Students shall be students in a school of engineering of recognized standing. Their membership shall cease at the annual meeting following the severance of their connection as students, unless they shall have transferred to another grade of membership.*

Prof. J. B. Babcock stated that the proposed amendments should induce students in technical schools to become members and at reasonable cost.

Voted, That the proposed amendments to the constitution be adopted.

* Transfer from Grade of Junior.

The President stated that, in accordance with the provisions of the Constitution relative to amendments, this matter will be presented to the membership for letter ballot which will be canvassed May 18, 1932.

The President presented proposed amendments to the By-Laws to provide as follows:

1. To fix the date of the September meeting as the fourth Wednesday of the month.

2. To provide for the election of Student Members and to fix dues for that grade.

The proposed amendments to the By-Laws are as follows, and are indicated by italics:

AMENDMENTS TO BY-LAWS

Article 1. Meetings

Regular meetings of the Society shall be held on the fourth Wednesday in January and September and on the third Wednesday of the other months, excepting July and August, unless otherwise authorized by the Board of Government.

Article 7. Election of Members

(Add new paragraph at end of Article 7)

An applicant for Student Membership shall submit a statement that he is a bona fide student in the Institution which he is attending. This statement shall be signed by the Dean, Registrar or other officer of the Institution acceptable to the Board of Government.

Article 8. Fees and Dues

(First Paragraph)

The entrance fee for Members and Associates shall be ten dollars, and for Juniors, five dollars; a Junior transferred to the grade of Member or Associate shall pay an additional fee of five dollars. *There shall be no entrance fee for Students. Students who transfer to another grade shall pay the entrance fee for that grade when the transfer is made.*

(Second Paragraph, First Sentence)

The annual dues, payable in advance at the Annual Meeting, shall be as follows: by Resident Members and Associates, ten dollars; by Non-Resident Members and Associates, six dollars; by Resident Juniors, five dollars; by Non-Resident Juniors, four dollars; *and by Students,*

three dollars, for a full year or fraction thereof.

Voted, That the proposed amendments to the By-Laws be adopted.

The President stated that, in accordance with the provisions of the By-Laws relating to amendments, this matter will be finally acted upon at the next meeting of the Society, May 18, 1932.

The President stated that he attended today the meeting of students at North-eastern University, at which there was presented the scholarship known as the Boston Society of Civil Engineers Scholarship, in memory of the late Desmond FitzGerald, to John L. Freiheit, a member of the class of 1932, in accordance with the vote of the Board of Government.

The President announced that at its meeting on March 16, 1932, the Board of Government had elected to Honorary Membership, Prof. C. Frank Allen, now the senior member of the Society, and that at the present meeting the diploma of membership would be presented. Previous to this presentation the President called on Prof. Charles B. Breed to read a biographical sketch of Professor Allen. Following this, the President presented the diploma of Honorary Membership to Professor Allen, who responded fittingly in accepting this honor.

The diploma read as follows:

Boston Society of Civil Engineers

In recognition of his many years of useful accomplishments as an engineer, author and teacher, and the wise counsel which has been so helpful to the numerous committees on which he has served —

CALVIN FRANCIS ALLEN

Past President and Senior Member

has been duly elected an

Honorary Member

of the

Boston Society of Civil Engineers

By direction of the Board of Government
March 16, 1932

(SEAL) HARRY E. SAWTELL,
President.

EVERETT N. HUTCHINS,
Secretary.

The President introduced Prof. Walter C. Voss, Associate Professor of Building Construction, Massachusetts Institute of Technology, and Consultant in Architectural Construction, who gave a paper on "Bond in Masonry Construction."

The paper was illustrated by lantern slides. A general discussion and question period followed the paper.

The meeting adjourned at 9.30 P.M.

EVERETT N. HUTCHINS, *Secretary*.

Designers Section

APRIL 13, 1932. — The regular meeting of the Designers Section was called to order at 6.10 P.M. by the Chairman, Lawrence Ropes, in the Affiliation Rooms.

The minutes of the March meeting were read and approved.

The Chairman called attention to the fact that a meeting in the fall would be set aside for the explicit purpose of allowing members of the Section to present

papers. A special invitation is extended to the younger men. Those interested should get in touch with the officers or executive committee.

The two speakers were Mr. W. W. Bigelow and Mr. O. G. Julian, both engineers with Jackson & Moreland. Their subject was the "Hardy-Cross Method for the Analysis of Continuous Frames." Mr. Bigelow discussed the elementary principles involved, and illustrated his remarks with the use of a model. Mr. Julian discussed in some detail the theory and mathematics involved.

Folders prepared by the speakers were provided for all those present. These folders contained information similar to that presented by Mr. Bigelow and Mr. Julian, and, in addition, several illustrative examples.

A general discussion followed the talks.

Forty-seven members and guests were present.

The meeting adjourned at 8.15 P.M.

HERMAN G. DRESSER, *Clerk*.

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

INDEX TO ADVERTISERS

	PAGE
ALGONQUIN ENGRAVING CO., INC., 18 Kingston St., Boston	v
ASPINWALL & LINCOLN, 46 Cornhill, Boston	iii
BARBOUR, FRANK A., Tremont Building, Boston	iv
BARROWS, H. K., 6 Beacon St., Boston	iii
BAY STATE DREDGING AND CONTRACTING CO., 62 Condor St., East Boston	viii
BLACK & BLUE PRINT CO., 71A Pearl St., Boston	viii
BLAKESLEE, ROLLINS CORP'N, 6 Beacon St., Boston	v
BRUNO & PETITTI, CONTRACTORS, 18 Tremont St., Boston	v
BRYANT, HENRY F., & SON, 334 Washington St., Brookline	v
BUFF & BUFF CO., Jamaica Plain	vi
CENTURY WOOD PRESERVING CO., Park Square Building, Boston	v
CHAPMAN VALVE MFG. CO., 71 A St., Boston	vii
COLEMAN BROS., 245 State St., Boston	vi
CRANDALL ENGINEERING CO., 134 Main St., Cambridge	ix
ELLIS, W. H., & SON CO., East Boston	vii
FAY, SPOFFORD & THORNDIKE, 44 School St., Boston	iii
FULLER & MCCLINTOCK, 170 Broadway, New York	iii
GOW COMPANY INC., 956 Park Square Building, Boston	viii
GRANDE, V. J., 100 Academy Hill Road, Boston	vi
GRAUSTEIN, EDWARD A., 6 Beacon St., Boston	iv
HOLZER, U., INC., 333 Washington St., Boston	vii
HUGHES, EDWARD F., 53 State St., Boston	vii
JACKSON & MORELAND, Park Square Building, Boston	iii
JENKINS BROS., 524 Atlantic Ave., Boston	vi
KIMBALL CO., RICHARD D., 6 Beacon St., Boston	v
LANZA, FRANK, & SONS, Kimball Building, 18 Tremont St., Boston	vii
LEIGHTON-MITCHELL CO., 99 Chauncy St., Boston	vi
LUNT MOSS CORP., 43 South Market St., Boston	v
MAIN, INC., CHAS. T., 201 Devonshire St., Boston	iv
MAKEPEACE, INC., B. L., 387 Washington St., Boston	Back cover
METCALF & EDDY, Statler Building, Boston	iii
MONKS & JOHNSON, 99 Chauncy St., Boston	iv
MONTAN TREATING CO., 141 Milk Street, Boston	vi
MOORE, LEWIS E., 73 Tremont St., Boston	iii
MULCARE, THOMAS, INC., 66 Western Ave., Boston	v
NATIONAL METER CO., 368 Congress St., Boston	vii
NAWN, HUGH, INC., 77 Floydell St., Boston	v
NEW ENGLAND CONCRETE PIPE CORP., 79 Milk St., Boston	ix
NEW ENGLAND FOUNDATION CO., INC., 38 Chauncy St., Boston	vi
NEW ENGLAND POWER ENGINEERING & SERVICE CORPN., 89 Broad St., Boston	vi
PACKARD, GEORGE A., 50 Congress St., Boston	iv
PETERS, A. C., Co., 46 Cornhill, Boston	vi
PIKE, EDWARD N., 38 Chauncy St., Boston	iv
PITTSBURGH TESTING LABORATORY, 101 Tremont St., Boston	iv
REIDY, MAURICE A., 44 School St., Boston	v
SCULLY CO., 238 Main St., Cambridge	vii
SHAW, FRANK R., 161 Devonshire St., Boston	vii
SIMPSON BROS. CORPN., 77 Summer St., Boston	vii
SNOW CO., FRANKLIN A., 216 Tremont St., Boston	vi
SOMERSET PRINTING CO., 32 Pemberton Sq., Boston	vii
STUART, T., & SON CO., 70 Phillips St., Watertown, Mass.	ix
THOMPSON & LIGHTNER, THE, CO., INC., 702 Beacon St., Boston	iii
THORPE, LEWIS D., 6 Beacon St., Boston	iii

	PAGE
TOMASELLO, A. G., & SON, 250 Stuart St., Boston	vii
TRAVERS-SANDELL, INC., 238 Main St., Cambridge	iv
TRIMOUNT DREDGING COMPANY, 10 State St., Boston	v
TURNER, HOWARD M., 12 Pearl St., Boston	iv
WESTON & SAMPSON, 14 Beacon St., Boston	iii
WHITNEY ENGINEERING CO., 100 Arlington St., Boston	iv
WHITMAN & HOWARD, 89 Broad St., Boston	iii
WOLF, EZEKIEL, 160 State St., Boston	iv
WORCESTER, J. R., & Co., 79 Milk St., Boston	iii
WRIGHT & POTTER PRINTING Co., 32 Derne St., Boston	vii

The advertising pages of the JOURNAL aim to acquaint readers with Professional and Contracting Services and Sources of Various Supplies and Materials. You would find it of advantage to be represented here.

LEWIS E. MOORE*Consulting Engineer*

73 TREMONT STREET
BOSTON, MASS.

ASPINWALL & LINCOLN

(WILLIAM S. CROCKER)

Civil Engineers

46 CORNHILL, BOSTON

FAY, SPOFFORD & THORNDIKE
Consulting Engineers

Investigations Reports Designs
Engineering Supervision Valuations
Port Developments Fire Prevention
Bridges Buildings Foundations
Water and Sewerage Systems
44 SCHOOL STREET, BOSTON

FULLER & McCLINTOCK
Engineers

NEW YORK, 170 Broadway

PHILADELPHIA, PA.
Pennsylvania Bldg.
15th and Chestnut Sts.

H. K. BARROWS*Consulting Hydraulic Engineer*

Water Power, Water Supply, Sewerage,
Drainage. Investigations, Reports, Valua-
tions, Designs, Supervision of Construction
6 BEACON ST. BOSTON, MASS.

METCALF & EDDY
Engineers

Harrison P. Eddy John P. Wentworth
Charles W. Sherman Harrison P. Eddy, Jr.
Almon L. Fales Arthur L. Shaw
Frank A. Marston E. Sherman Chase
Water, Sewage, Drainage, Garbage and
Industrial Wastes Problems
Valuations Laboratory
STATLER BUILDING BOSTON, MASS.

THE THOMPSON & LICHTNER CO., INC.BOSTON *Engineers* CHICAGO

Designs and Engineering Supervision
Investigations, Testing and
Inspection of Structural Materials
Concrete Quality Control
Marketing and Production Service

Research Laboratory, 702 BEACON ST., BOSTON, MASS.

LEWIS D. THORPE*Civil and Sanitary Engineer*

Water Works, Sewerage and Sewage
Disposal

Supervision of Construction and Operation

6 Beacon Street
BOSTON, MASS.

WESTON & SAMPSON

ROBERT SPURR WESTON G. A. SAMPSON

Laboratory for the Analysis of Water,
Sewage, Filtering Materials, etc., Design,
Inspection and Supervision of Water Puri-
fication and Sewage Disposal Plants.

14 BEACON STREET, BOSTON, MASS.

WHITMAN & HOWARD*Civil Engineers*

(Established in 1869)

89 Broad Street Room 526
BOSTON

J. R. WORCESTER & CO.
Engineers

BUILDINGS BRIDGES FOUNDATIONS
STEEL AND REINFORCED CONCRETE
DESIGNS INVESTIGATIONS
EXPERT TESTIMONY
CEMENT AND SAND TESTING

79 MILK STREET BOSTON, MASS.

JACKSON & MORELAND*Engineers*

BOSTON

NEW YORK

CHAS. T. MAIN, Inc.

ENGINEERS

201 Devonshire St., Boston, Mass.

Design and Supervision of Construction

Industrial Buildings

Electrical, Steam and Hydraulic
Engineering

Valuations and Reports

Consulting Engineering

CHARLES T. MAIN
F. M. GUNBY
HARRY E. SAWTELL
W. F. UHL

CHARLES R. MAIN
A. W. BENOIT
MARCUS K. BRYAN
R. A. MONCRIEFF

HOWARD M. TURNER

Consulting Engineer

Investigations, Valuations, Plans,
Supervision of Construction, Water
Power, Water Supply, Public Utility
and Industrial Properties

12 Pearl Street : : : Boston

TRAVERS-SANDELL, Inc.

WATERPROOFING

Engineers and Contractors

ALL WORK GUARANTEED ON INTERIOR
OR EXTERIOR OF MASONRY STRUCTURES

238 MAIN ST., CAMBRIDGE, MASS.

Telephone, Porter 4827

The Whitney Engineering Company

100 Arlington St., Boston

STRUCTURAL ENGINEERS
RIVETED OR WELDED DESIGN

EDWARD N. PIKE

Consulting Engineer

Charles Chauncy Bldg., 38 Chauncy St.
Phone Hubbard 7240-7241 Boston, Mass.

Steel Structures Foundations Bridges
Appraisals Supervision of Construction
Re-enforced Concrete Labor Saving Equipment
Mill, Shop and Field Inspection
Design and Supervision of Welded Steel Structures
Design of Industrial Plants

MONKS & JOHNSON

ARCHITECTS—ENGINEERS

99 Chauncy Street

Boston

FRANK A. BARBOUR

Consulting Engineer

Water Supply, Water Purification
Sewerage and Sewage Disposal

Tremont Building, Boston, Mass.

EDWARD A. GRAUSTEIN

Consulting Engineer

WATER POWER
HYDRAULIC—STRUCTURAL—CIVIL
SOILS TESTING LABORATORY

Investigations—Valuations—Court Work
Design and Supervision

6 BEACON STREET - - BOSTON

GEORGE A. PACKARD

MINING .. ENGINEER

EXAMINATIONS AND REPORTS

Supervision of Exploration, Purchase,
Development and Operation

50 CONGRESS STREET, BOSTON

EZEKIEL WOLF

Reg. Patent Attorney and Engineer
Counsellor at Law

Patent and Trade-Mark Causes

Consultation by Appointment

160 STATE ST., BOSTON, MASS.

Telephone Richmond 3620

Pittsburgh Testing Laboratory

Inspection Testing Analysis
Research

Boston Office - 101 Tremont St.
Branch Offices in the Principal Cities

RICHARD D. KIMBALL CO.

Consulting and Designing Engineers

Mechanical, Electrical and Sanitary

6 BEACON STREET
BOSTON, MASS.**H. F. BRYANT & SON***Consulting Engineers*

CIVIL - ARCHITECTURAL - LANDSCAPE

334 WASHINGTON STREET
BROOKLINE**LUNT MOSS CORP.
ENGINEERS**Water Supply Equipment
Shallow and Deep Well Pumps
Westco Shallow Well Turbine Pumps
Sterling Deep Well Turbine Pumps
Concrete Septic Tanks
Artesian Wells Drilled43 SO. MARKET STREET, BOSTON, MASS.
Telephone RICHMOND 0970**HUGH NAWN Inc.**

CONSTRUCTORS

77 Floydell Street
Boston, Mass.**TRIMOUNT DREDGING COMPANY**

10 STATE STREET

BOSTON

HERBERT T. GERRISH
PRESIDENT**MAURICE A. REIDY**

Consulting Engineer

STRUCTURAL DESIGNS FOUNDATIONS

44 SCHOOL STREET
BOSTON, MASS.**Blakeslee Rollins Corporation****CONTRACTORS**

6 Beacon Street Boston, Mass.

Foundations of all kinds
Wharves and Dock ConstructionD. A. BLAKESLEE, President
CLARENCE BLAKESLEE, Vice-President
J. W. ROLLINS, Vice-President and Treasurer
WALTER G. CHEEVER,
General Superintendent

Telephone, Haymarket 1761

THOMAS MULCARE, INC.

66 WESTERN AVENUE

BOSTON, MASS.

CONCRETE

PLAIN AND REINFORCED

PHOTO ENGRAVERSCOLOR PLATES - HALF-TONES
LINE PLATES**ALGONQUIN**

ENGRAVING CO. Inc.

18 Kingston Street, Boston, Mass.
Tel. HAN 4855**BRUNO & PETITTI**

CONTRACTORS

WATERWORKS, SEWERS, HIGHWAYS AND
CONCRETE CONSTRUCTION

18 Tremont Street Boston, Mass.

PRESERVATIVELY TREATED

*Timbers, Lumber, Ties,
Poles and Piling*Century Wood Preserving Company
Park Square Bldg., Boston, Mass.

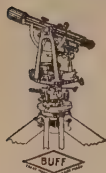


Transits and Levels

WORLD FAMOUS
FOR 71 YEARS

George L. Buff
Louis F. Buff
Henry A. Buff
Will J. Buff
Will J. Buff, Jr.

BUFF PRECISION is continuously in the forefront



All Makes Repaired
at Reasonable Cost

Buff & Buff Co.

Jamaica Plain,
Mass.

Compliments of

*New England Power Engineering
& Service Corporation*



**A Symbol
of Quality**

JENKINS BROS.

524 Atlantic Ave.
BOSTON, MASS.

MONTAN. TREATING CO.

WOOD PRESERVATION

141 Milk Street

BOSTON, MASS.

FRANKLIN A. SNOW CO.

Contractors for Public Works

216 Tremont St., Boston, Mass.

ELECTRICAL UNDERGROUND CONDUITS

EARL M. MAJOR, Treasurer

Liberty 9406

A. C. Peters Co., Inc.

46 CORNHILL
BOSTON

GENERAL CONTRACTORS

INDUSTRIAL BUILDINGS
BRIDGES - FOUNDATIONS
REINFORCED CONCRETE CONSTRUCTION

Leighton-Mitchell Company

BUILDERS

99 Chauncy Street, Boston

Telephones Hancock 3790 - 3791

V. J. GRANDE

General Contractor

100 ACADEMY HILL ROAD

BOSTON, MASS.

New England Foundation Co., Inc.

Engineering and Construction

Simplex Concrete Piles

Caissons — Difficult Foundations

38 CHAUNCY STREET

BOSTON, MASS.

COLEMAN BROS., Inc.

General Contractors and Builders

Main Office

245 STATE STREET, BOSTON

HUBBARD 4880

Dredging Pile Driving
Sea Wall and Bridge Building
Submerged Pipe and Foundations

W. H. ELLIS & SON COMPANY

EAST BOSTON, MASSACHUSETTS

**THE CHAPMAN VALVE
MFG. COMPANY**

71 A Street - BOSTON, MASS.

VALVES

FOR ALL SERVICES

SLUICE GATES - SHEAR GATES
 FLAP VALVES

Telephone Hubbard 0137

FRANK LANZA & SONS
CONTRACTORS

Steam Shovel Excavating and
 Highway Construction

Room 242, KIMBALL BUILDING
 18 TREMONT ST., BOSTON, MASS.

Somerset Printing Co.

COMMERCIAL PRINTING

ENGRAVING . PLATE PRINTING
 RELIEF PRINTING : EMBOSING

32 PEMBERTON SQUARE, BOSTON
 TELEPHONE - - - HAYMARKET 4216

GENERAL DRAFTING SERVICE

Engineering Draftsmen
Machine Designers

Special Machinery, Jigs, Fixtures and Tools

FRANK R. SHAW

161 Devonshire Street - - Boston, Mass.
 Liberty 7249

U. HOLZER, Inc.

BOOKBINDER

333 Washington Street (Opp. Milk Street)
 Or 24 Province Street Main Shop at Hyde Park

Books Bound, Charts Mounted, Portfolios,
 Lettering, Photographs Mounted

SIMPSON BROS. CORPORATION

Engineers and Contractors
 for

Reinforced Concrete Construction

Asphalt, Concrete and Vulcanized
 Pavements

A. G. TOMASELLO & SON, Inc.
Contractors

*Steam Shovel Excavating, Foundations
 and Public Works*

250 STUART STREET - BOSTON, MASS.

TELEPHONE HANCOCK 7270

JOS. A. TOMASELLO, Pres. and Treas.

NATIONAL METER COMPANY

Water, Oil, and Gasoline
Meters

368 Congress Street
 BOSTON - - - MASS.

EDWARD F. HUGHES

Waterworks Contractor
 Public and Private Water Supply
Artesian and Driven Wells

Foundation Borings

53 State St. Room 1102 Boston

Established 1865

THE SCULLY COMPANY

Building Construction

238 Main Street

CAMBRIDGE, MASS.

Wright & Potter
Printing Company

COMMERCIAL PRINTERS

32 Derne Street - Boston, Mass.

Tel. Capitol 2000, 2001, 2002

Bay State Dredging & Contracting Co.



CONTRACTORS

Wharves and Timber Work
Bridges — Sea Walls — Breakwaters
Heavy Masonry Construction
Sub-Marine Pipe Lines

62 Condor Street, East Boston, Mass.

FOUNDATIONS

ENGINEERS AND CONTRACTORS

The Gow Company Inc.

956 Park Sq. Building
Boston

GOW CAISSONS
RAYMOND CONCRETE PILES
SOIL TEST BORINGS

90 WEST ST., NEW YORK CITY

111 W. MONROE ST., CHICAGO

REPRODUCTIONS

On Tracing Cloth or Paper by Gelatine Lithograph Process

BLUE PRINTS

BLACK & BLUE PRINT COMPANY

242 PURCHASE STREET, BOSTON TEL. LIB. 8925

Please mention the Journal when writing to Advertisers

T. STUART & SON COMPANY

General Contractors

70 PHILLIPS STREET
WATERTOWN, MASSACHUSETTS

THE CRANDALL ENGINEERING COMPANY

CONSULTING AND
CONSTRUCTING ENGINEERS

DESIGN of Floating, Basin, and Railway Dry Docks,
Wharves, Piers, Bridges, etc.

CONSTRUCTION of these and other Engineering
Structures

134 MAIN STREET, CAMBRIDGE, MASS.

SPECIFY THE STRONGER, MORE DURABLE PIPE FOR SEWERS,
DRAINS AND CULVERTS

Use Machine Made Plain and
Reinforced Concrete Pipe
NEW ENGLAND CONCRETE PIPE CORPORATION

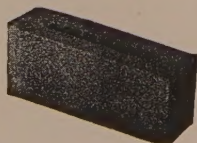
79 Milk Street, Boston, Massachusetts

Plant
NEWTON, MASS.

HUBbard 9373

CINUCOR MASONRY UNITS

ARE LIGHT,
TOUGH AND
STRONG



*Used where fire safety,
sound-proofness, and in-
sulation are essential.*

CINDER CONCRETE UNITS CORPORATION, 201 Devonshire Street, Boston, Mass.

COMMITTEES

NOMINATING COMMITTEE

Past Presidents (Members of the Committee)

CHARLES M. ALLEN

FRANK A. MARSTON

CHARLES B. BREED

HENRY B. ALVORD
CHARLES W. BANKS
GEORGE E. HARKNESS
(Term expires March 1933)

W. W. BIGELOW
ERWIN HARSCH
W. D. HENDERSON
(Term expires March 1934)

SPECIAL COMMITTEES

Program

RALPH W. HORNE, *Chairman, ex officio*

JOHN B. BABCOCK, 3d
WILLIAM W. BIGELOW
HARRY P. BURDEN
E. SHERMAN CHASE
LUZERNE S. COWLES

HOWARD A. GRAY
EVERETT N. HUTCHINS
WILLIAM J. KEEFE
KARL R. KENNISON
HARVEY B. KINNISON

CHARLES R. MAIN
JAMES H. O'CONNOR
HOWARD M. TURNER
EDWARD WRIGHT

Publication

EVERETT N. HUTCHINS, *Chairman*

HAROLD K. BARROWS
FRANK W. GILCREAS
F. WM. HALEY
ARTHUR J. HARTY

LEROY M. HERSUM
HERBERT D. HURLEY
RAY H. LINDGREEN

RALPH E. RICE
TRUMAN H. SAFFORD
JOHN P. WENTWORTH

Library

HENRY B. ALVORD, *Chairman*

EDWARD S. AVERELL
HARRISON P. EDDY, JR.
ALBERT HAERTLEIN

ERWIN HARSCH
WALDO F. PICE

KENNETH C. REYNOLDS
FREDERIC N. WEAVER

Subsails of Boston

HARRY E. SAWTELL, *Chairman*

J. STUART CRANDALL
IRVING B. CROSBY
CARROLL A. FARWELL

HEYWARD S. FRENCH
CHARLES D. KIRKPATRICK

CHARLES W. ROBINSON
ALBERT C. TITCOMB

Social Activities

RICHARD W. SHERMAN, *Chairman*

EDWARD S. AVERELL
JOHN J. CAMPOBASSO
HUGH D. CHASE
WILLIAM H. FITZGERALD

RICHARD H. HAMILL
JOHN H. HARDING
A. ALBERT MINICHIELLO

ARTHUR W. PETERSON
ALFRED T. STAMP
LEON B. TURNER

Membership and Publicity

ARTHUR L. SHAW, *Chairman*

GEORGE G. BOGREN
HERBERT S. CLEVERDON
ATHOLE B. EDWARDS

JOHN F. GERMAINE
WILLIAM D. HENDERSON
FRANK L. LINCOLN

JOHN F. PIERCE
WALTON H. SEARS
WALTER C. VOSS

Relation of Sections to Main Society

JOHN B. BABCOCK, 3d, *Chairman*

S. E. COBURN
ARTHUR W. DEAN
GORDON W. FAIR

JOHN B. KOMICH
FRANCIS T. McAVOY

L. G. ROPES
HENRY C. SHELLS

Registration and Licensing of Engineers

CHARLES B. BREED, *Chairman*

RICHARD K. HALE

FRANK E. WINSOR

Research

FRANK A. MARSTON, *Chairman*

H. K. BARROWS
THOMAS R. CAMP
J. STUART CRANDALL

A. B. EDWARDS
ALBERT HAERTLEIN

HARRY E. SAWTELL
FRANK B. WALKER

Run-off

ARTHUR T. SAFFORD, *Chairman*

HARRY P. BURDEN
ARTHUR C. EATON
HENRY GOODNOUGH
WILLIAM D. HENDERSON
RALPH W. HORNE
S. STANLEY KENT

H. B. KINNISON
WILLIAM A. LIDDELL
R. R. MARSDEN
WILLIAM NOYES
L. B. PUFFER

CALEB MILLS SAVILLE
HOWARD M. TURNER
WILLIAM F. UHL
ARTHUR D. WESTON
FRANK E. WINSOR

Welfare

ARTHUR W. DEAN, *Chairman*

STUART E. COBURN
FRANCIS H. KINGSBURY

FRANCIS T. McAVOY
LAWRENCE G. ROPES

Desmond Fitzgerald Award

CARROLL A. FARWELL, *Chairman*

GEORGE E. HARKNESS

C. FREDERICK JOY, JR.

Board of Reference

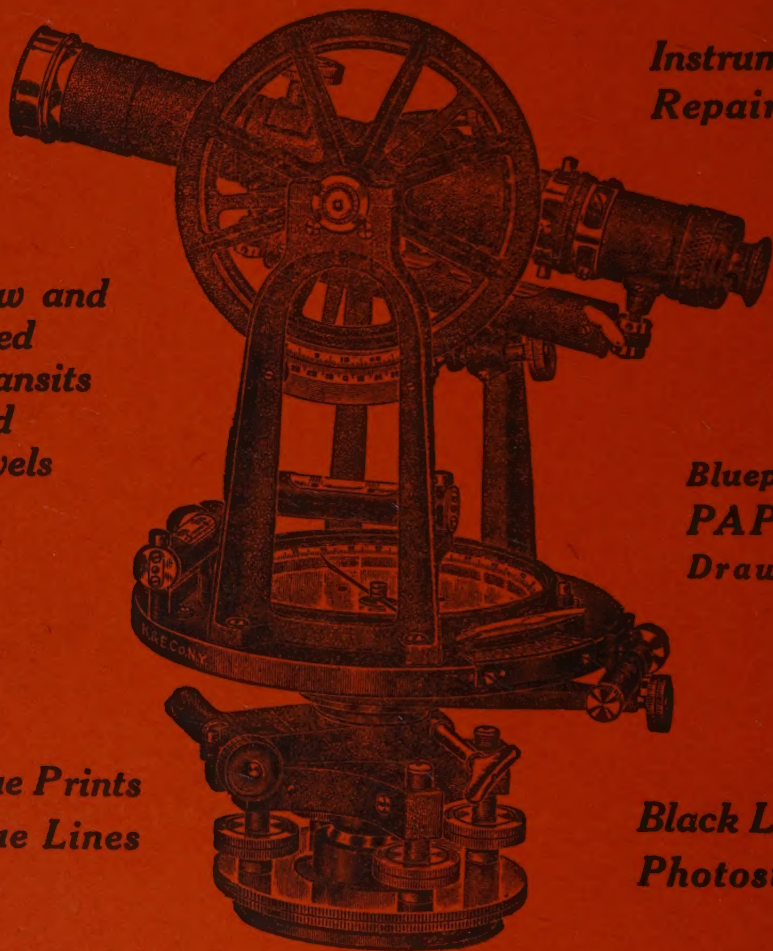
EUGENE E. PETTEE, *Chairman*

EDWARD S. LARNED

MARK LINENTHAL

CHARLES R. MAIN

**Field and Office Equipment and Supplies
FOR THE ENGINEER**



**Instrument
Repairing**

**New and
Used
Transits
and
Levels**

**Blueprint
PAPER
Drawing**

**Blue Prints
Blue Lines**

**Black Lines
Photostats**

DRAFTING ROOM FURNITURE

B. L. MAKEPEACE, Inc.

387 WASHINGTON STREET, - 462 BOYLSTON STREET

*Including H. H. SULLIVAN, INC., successors to FROST & ADAMS CO.,
64 High Street, Boston*

BOSTON, MASS.